ULY 1961
LUME 4 • NUMBER 7

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- Stelzried — A Cooled, Negative Conductance, Degenerate Parametric Amplifier.
- Alexander & Barrett — Methods of Using Pure Noble Gas in Gas Switching Tubes
- Shelton — Compact, Multihole, Waveguide Directional Couplers

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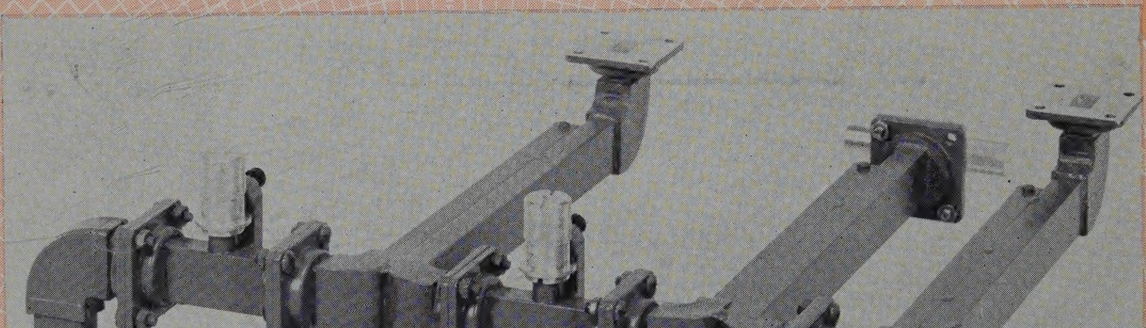

In This Issue . . . **RECENT PROGRESS IN MICROWAVE RADIO COMMUNICATIONS**

COAXIAL TEST EQUIPMENT

INSTRUMENT	MODEL NO.	FREQ KMC/SEC	PRICE	COMMENT
SLOTTED SECTIONS	N101A N101B *V101A *V101B N110A	1.00- 4.00 4.00-10.00 1.00- 4.00 1.00- 4.00 0.20- 4.00	$470.00 $440.00 $470.00 $470.00 $550.90	Type N or C adapter connector supplied for N101A, B
FERRITE ISOLATORS	N157A	1.00- 4.00	$390.00	
FIXED ATTENUATORS	N180A,B,C,D	1.00-11.00	$ 42.00	3, 6, 10, 20 db
TUNABLE PROBES	B200A B202A	1.00-12.40 0.35- 1.40	$145.00 $225.00	1N23B supplied 1N21B supplied
DETECTOR MOUNTS **Tunable** **Untuned**	N200A N210A **N210B	1.00-12.40 0.10-10.00 0.10-10.00	$145.00 $ 50.00 $ 55.00	1N23B crystal supplied
THERMISTOR MOUNTS **Broadband** **Temp Compensated**	N215A N217A	0.50-10.50 0.50-10.50	$ 75.00 $140.00	Z215L element supplied
THERMISTOR HEAD	N218A	0.01-10.00	$145.00	Used with Model B831A
DOUBLE STUB TUNER	N300A	1.00-10.00	$ 90.00	
SLIDE SCREW TUNER	N311A	1.00-10.00	†	
FREQUENCY METERS, DIRECT READING	N410A N414A	1.00- 4.00 4.00-11.00	$495.00 $495.00	Accuracy 0.08% Accuracy 0.10%
DIRECTIONAL COUPLERS (20 DB)	N616D N617D	0.25- 1.00 1.00- 4.00	$160.00 $150.00	
KLYSTRON TUBE MOUNT	N761A		$ 95.00	Z761P cable not supplied
KLYSTRON TUBE MOUNT	Z762B		$145.00	Z762P cable supplied

*Mating coax dim. 7/8" all others 3/8"   **Model N210B has built in DC return.   †Price will be furnished on request.

WAVEGUIDE TEST EQUIPMENT

Y .622x.311	K* .420x.170	U* .280x.140	Q .224x.112	M .148x.074	E 122x.061	F .080x.040	G .051x.0255	FXR SERIES PREFIX WAVEGUIDE SIZE IN INCHES (I.D.)
12.40x18.00	18.00-26.50	26.50-40.00	33.00x50.00	50.00-75.00	60.00x90.00	90.00-140.00	140.00x220.00	**FREQUENCY RANGE IN KMC/SEC**
Y102A $545	K102A $545	U102A $545	Q103A $1100	M103A $995	E103A $1650	F105A $1400	G105A $1400	**SLOTTED SECTIONS** Fixed W.C.
Y115A				TYPE Z116A CARRIAGE $160				Interchangeable W.C.
			Q151A $110	M151A $100	E151A $190			**ATTENUATORS** Flap
Y155A $ 90	K155A $135	U155A $170						Semiprecision
						F163A $975	G163A $975	Precision Calibrated
Y164A $275	K164A $425	U164A $450	Q164A $825	M164A $800	E164A $1200			Precision Direct Reading
								Fixed
Y175A $115	K175A $240	U175A $250	Q175A $475	M175A $425	E175A $675	(Values to 30DB)		Fixed Precision
								40DB Step
Y157A $220	K157A $240							**FERRITE ISOLATORS**
Y205B $175	K205B $175	U205B $200 U206B $200	Q206B $210	M208A $325 M206B $210	E208A $400 E206C $350	F208A $400	G208A $400	**CRYSTAL DETECTOR MOUNTS** Tuneable
Y212A $ 80	K212A $ 80	U212A $ 80						Fixed
								MATCHED BOLOMETER MOUNTS
Y216A $110	K216A $150	U216S $270						**THERMISTOR MOUNTS**
Y218A $210	K218A $250	U218S $400						**THERMISTOR HEADS TEMPERATURE COMPENSATED**
Y311A $130				M311A $195				**TUNERS** Slide screw
Y312C $135	K312C $155	U312B $170	Q312B $235	M312C $245	E312C $390	F313A $775	G313A $775	E/H
						F314A $950	G314A $950	**PRECISION PHASE SHIFTERS**
								DIRECT READING FREQUENCY METERS Precision
Y410A $210	K410A $230	U410A $250						Reaction
			Q410X $325	M410X $300	E410X $500	F412A $750	G412A $750 G413A $800	Reaction, micrometer
								Transmission
Y501A $ 24	K501A $ 30	U501A $ 35	Q501A $ 95	M501A $ 90	E501A $150	F501A $150	G501A $150	**TERMINATIONS** Fixed
Y502A $ 50	K502A $ 70	U502A $ 75						Sliding
								High power
Y510A $450	K510A $480	U510A $625						**STANDARD MISMATCHES** VSWR 1.00
Y510B $325	K510B $340	U510B $525						VSWR 1.05
Y510C $275	K510C $280	U510C $450						VSWR 1.10
Y510D $225	K510D $240	U510D $280						VSWR 1.20
Y510E $325	K510E $340	U510E $350						VSWR 1.50
								WAVEGUIDE-TO-COAX ADAPTERS
Y610A-D $100 Models A-3DB, B-6DB, C-10DB, D-20DB	K610A-D $165	U610A-D $185		M610A-D $500				**DIRECTIONAL COUPLERS** Multihole
Y612D $ 55	K612D $110					Models D-20DB, E-25DB		Crossguide
Y620A $ 40	K620A $ 45	U620A $ 55	Q620A $ 65	M620A $ 60	E620A $110	F620A $275	G620A $275	**WAVEGUIDE TEES** Series
Y621A $ 40	K621A $ 45	U621A $ 55	Q621A $ 65	M621A $ 60	E621A $110	F621A $275	G621A $275	Shunt
Y622A $ 54	K622A $ 65	U622A $ 80	Q622A $100	M622A $100	E622A $170	F622A $325	G622A $325	Hybrid
Y623B $ 32 Y624B $ 32	K623B $ 38 K624B $ 38	U623B $ 42 U624B $ 42	Q623B $ 55 Q624B $ 55	M623B $ 50 M624B $ 50	E623B $ 90 E624B $ 90	F623A $275 F624A $275	G623A $275 G624A $275	**WAVEGUIDE BENDS** 90° E-plane 90° H-plane
Y625A $ 60	K625A $ 60	U625A $ 70	Q625A $100	M625A $100	E625A $100	F625A $100	G625A $100	**WAVEGUIDE 90° TWISTS**
Y630C $145	K630C $155	U630B $150	Q630B $155	M630C $160	E630B $250	F631A $275	G631A $275	**PRECISION SLIDING SHORTS**
Y634A $ 35	K634A $ 38	U634A $ 38	Q634A $ 50	M634A $ 50	E634A $ 50	F634A $ 85	G634A $ 85	**STRAIGHT WAVEGUIDE SECTIONS (Min. length)**
Y638A $125	K638A $150	U638A $175	Q638A $120	M638A $125	E638A $250	F638A $200	G638A $200	**STANDARD GAIN HORNS**
Y641A $250 Y641AE $275	K641A $275 K641AE $300	U641A $300 U641AE $325						**WAVEGUIDE SWITCHES**
								SHIELDED TUBE MOUNTS
			Q780A $165	M780A $160	E780A $250	F781A $475	G781A $475	**HARMONIC GENERATORS**
Z910B $ 7	Z910B $ 7	Z910B $ 7	Z910C $ 7	Z910C $ 7	Z910C $ 7			**WAVEGUIDE STANDS**

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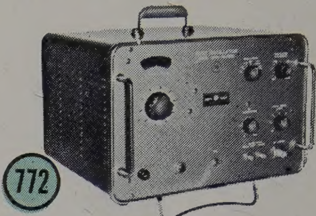


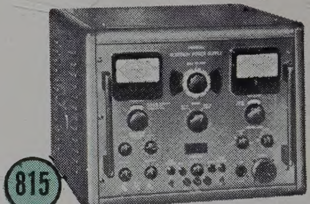
SIGNAL SOURCES

- 950 to 2000 MC.
  Model L772A $1340
- 1900 to 4000 MC.
  Model S772A $1340
- 3950 to 8200 MC.
  Model C772A $1340
- 7000 to 11000 MC.
  Model X772A $1340

TEMPERATURE COMPENSATED POWER METER

- Power Range, full scale —20DBM or 0.010 MW. to + 5DBM or 3.00 MW.
- Type 218 Heads required

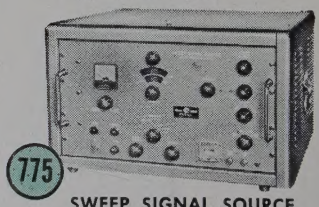
Model B831A • $335
Model B832T (Transistorized) • $450



UNIVERSAL KLYSTRON POWER SUPPLY

- Beam: 200-3600V
  Grid: 0 to +150V; 0 to —300V
  Reflector: 0-1000V

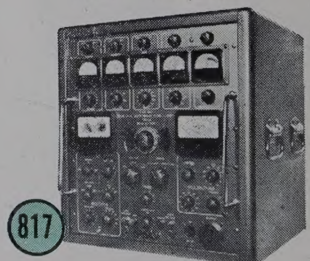
Model Z815B • $1350



SWEEP SIGNAL SOURCE

- Freq. Range: 8200-12400 MC.
- Provisions for AGC

Model X775A • $2900



UNIVERSAL MICROWAVE POWER SUPPLY

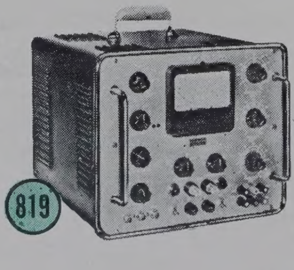
- Helix: 0-3500V
- Filament: 0-15V D.C.
- Separate Grid Voltages #1, #2, #3, #4 plus Collector and Anode Voltages

Model Z817A • $2650

STANDING WAVE AMPLIFIER

- Full scale sensitivity, $0.1\mu V$ signal-to-noise ratio 3:1
- Tunable 1000 cps filter

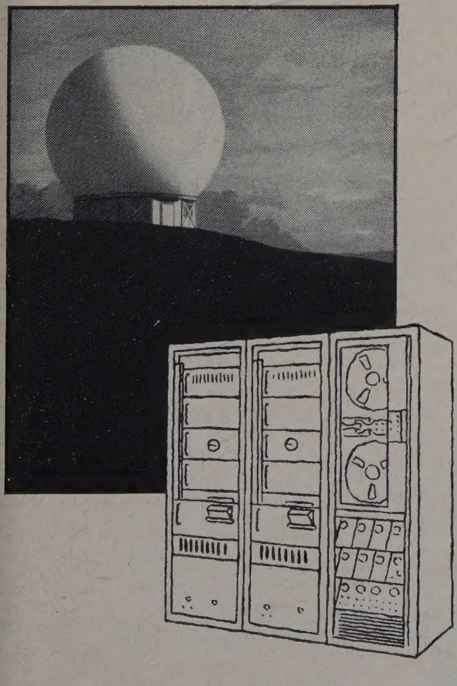
Model B812A • $225



KLYSTRON POWER SUPPLY

- Beam: 300-1000V at 85 MA.
- Grid: 0 to +150V; 0 to —300V
- Reflector: 0-900V

Model Z819A • $625



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Performance of A 20 KW CW X-Band Klystron Amplifier

Generalized Linear Radar Analysis

Recent Advances In Low-Noise Traveling-Wave Tubes

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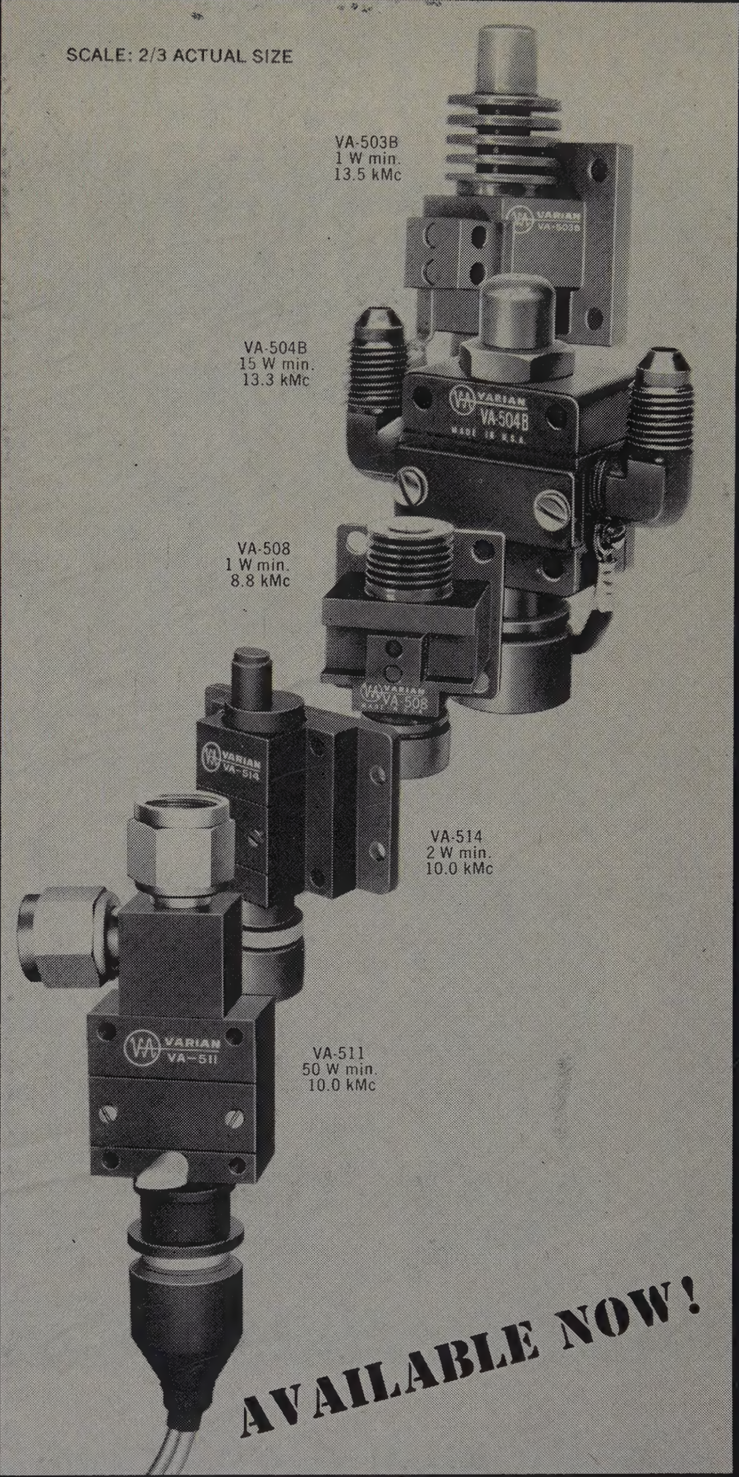
FOR CW ILLUMINATORS AND NAVIGATION

LOW NOISE OSCILLATORS

1 WATT TO 50 WATTS



Varian Associates' family of low-noise oscillator klystrons assures superior performance in such applications as CW illuminators, fixed-frequency doppler navigation transmitters, and similar uses.

All tubes in this low-noise family are two-cavity klystron oscillators. All are fixed-frequency. All are electrostatically focused. They cover a wide power range (from 1 W to 50 W). Tubes in K_u-band include the air-cooled VA-503B and the liquid-cooled VA-504B. Tubes in X-band include the air-cooled VA-514 and VA-508 and the liquid-cooled VA-511. All are available now.

Characteristics of the VA-511 are typical of the oscillators in this group. The VA-511 produces 50W minimum power at 10 kMc, and operates at 10 kV, 60 milliamperes. FM noise is less than 1 cycle. Weight, less than 24 oz.; size: 6¼ in. x 2¼ in. x 1¾ in.

For additional technical information on this fine family of klystron oscillators, address Tube Division.

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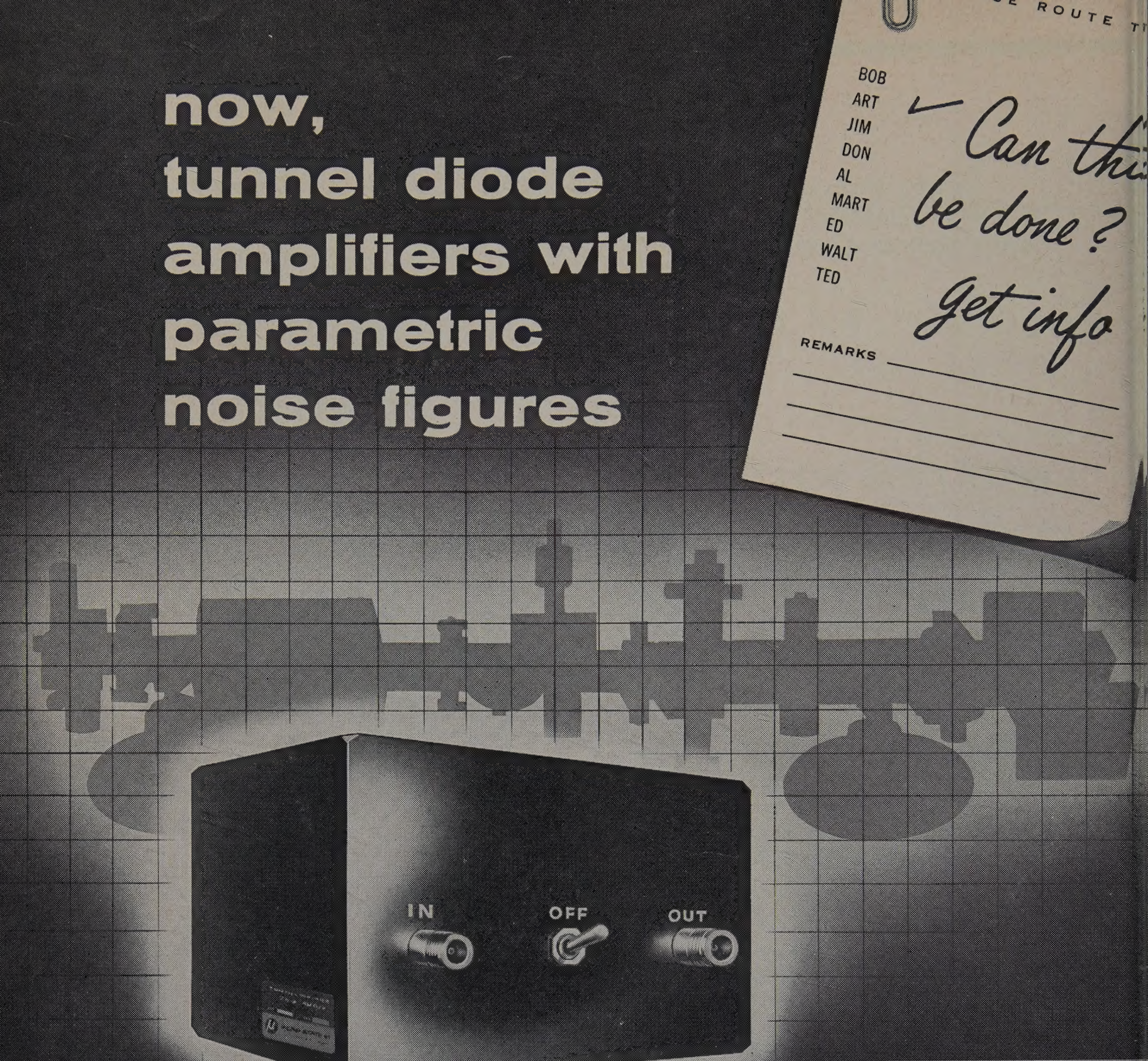

now, tunnel diode amplifiers with parametric noise figures

the simple approach to low noise

GALLIUM ANTIMONIDE TUNNEL DIODE AMPLIFIERS: Stable, high gain GaSb Tunnel Diode Amplifiers with noise figures from 2.5 to 3.5 db are now available. These units cover frequency ranges from 125 to 1400 mc with bandwidths to 6%. Octave bandwidth units are also available. The over-all quality of these amplifiers is a direct result of Micro State's creative capability and integrated design approach.

FROM BASIC MATERIAL — TO SEMICONDUCTOR DEVICE — TO MICROWAVE COMPONENT

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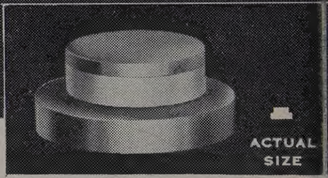
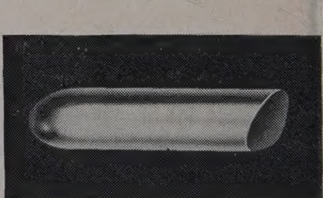


GaSb TUNNEL DIODES: These diodes have cutoff frequencies up to 4 KMC. Shot noise constants as low as 0.7, compared to 1.3 for germanium, permit the construction of tunnel diode amplifiers with parametric noise figures.



GaSb MATERIAL: Single crystal GaSb is offered for device applications. Undoped material, and tellurium, or zinc doped GaSb is available for the fabrication of low noise tunnel diodes.

8 MATCHED PRECISION COAXIAL ATTENUATORS

Covering the frequency range from DC to 12.4 KMC

MODEL AS-1 ATTENUATOR SET

This set was specially designed for use as working standards in laboratories, and inspection and quality control departments. It includes Weinschel Model 50 attenuators and Weinschel Model 210 attenuators in attenuation values of 3, 6, 10 and 20 DB covering the frequency range of DC to 12.4 KMC. These attenuators, which are supplied in a solid walnut, velvet-lined case, offer the following exclusive Weinschel features:

MAXIMUM STABILITY Because Weinschel film resistors are used, these attenuators are extremely stable even under peak pulse power and temperature and humidity cycling.

STAINLESS STEEL CONNECTORS To give maximum life with minimum wear, these attenuators are equipped with stainless steel connectors, eliminating corrosion and plating chips while giving long years of useful life.

CLOSE CONNECTOR TOLERANCE To assure proper mating of the connectors, the critical dimension of the inner contact depth is held to ±0.005 inches, even closer than NBS requirements for testing.

CERTIFICATE OF CALIBRATION A plastic laminated Certificate of Calibration showing calibration data for each attenuator is supplied with the set. The certificate gives DC resistance and insertion loss at 3 frequencies for each attenuator.

Write for Weischel Engineering Bulletin 333 for full information and prices on the AS-1 attenuator set. For special attenuators to meet other requirements, contact our Application Engineering Department.

PRECISION MICROWAVE MEASUREMENT COMPONENTS, INSTRUMENTS AND SYSTEMS

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MICROVIEWS

OF THE MONTH

71 ▶ **RECENT PROGRESS IN MICROWAVE RADIO COMMUNICATIONS**

Leang P. Yeh

Microwave Radio Communication Systems are becoming increasingly important in the field of telecommunications due to advancements in the art. This paper summarizes the recent progress from the system and propagation viewpoint by discussing Line-of-Sight and Over-the-Horizon Systems and the new developments which have been made in these systems.

79 ▶ **A COOLED, NEGATIVE CONDUCTANCE, DEGENERATE PARAMETRIC AMPLIFIER**

C. T. Stelzried

A simplified theory is presented for the degenerate parametric amplifier with circulator. Bandwidth and amplifier noise temperature are derived in terms of varactor and circuit parameters and gain. A varactor figure of merit is presented. The theory is verified for a liquid-nitrogen-cooled 960 Mc parametric amplifier with 20 db gain, 20 Mc bandwidth and 36°K noise temperature.

85 ▶ **METHODS OF USING PURE NOBLE GAS IN GAS SWITCHING TUBES**

Herbert C. Alexander and Arthur G. Barrett

Gas switching tube performance at high power levels depends upon the physical mechanism which achieves deionization. This paper discusses the attachment, recombination and diffusion mechanisms. Three methods are presented for realizing the switching efficiency of pure noble gases under controlled diffusion conditions. One method using the folded cylinder tube switches 50 megawatts peak power and 300 kilowatts average power at UHF. The addition of keep alive electrodes extends the power operating range of this tube down to a few hundred watts.

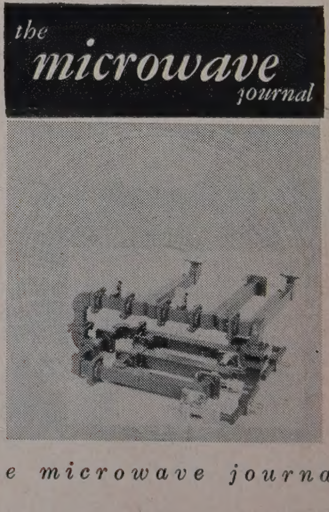
89 ▶ **COMPACT, MULTIHOLE, WAVEGUIDE DIRECTIONAL COUPLERS**

W. Shelton

This paper presents design procedures for compact, broadband, multihole, waveguide directional couplers in X- and Ku-band. Also, curves are given for X- *and S-band side wall couplers. Size reduction techniques for waveguide directional couplers in any band are explained. These compact couplers do not have high directivity, but high directivity is not always a requirement. From this article, the design engineer can design a large number of waveguide directional couplers.*

OUR COVER

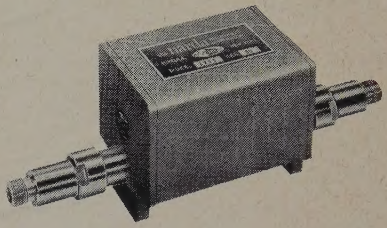
Shown is the R. F. section of a 12.4 - 18 Gc outphasing receiver. The purpose of this unit, in conjunction with an I.F. hybrid, is to suppress the image of a superheterodyne receiver. The R.F. section consists of an upper and lower deck. The upper deck has one 3 db and two 9 db directional couplers and two attenuators. The signal and local oscillator inputs are in the top deck, which serves as a strong signal mixer. The lower deck has three 3 db couplers, a power divider and four Sage mixers. The minimum image suppression of the receiver is 18 db. See page 89.



new! NARDA ferrite isolators

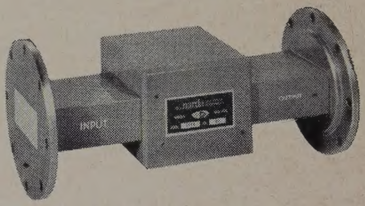
designed and manufactured by NARDA MICROWAVE!

• broadband coaxial ferrite isolators



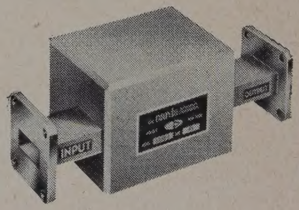
Excellent electrical characteristics with extreme versatility! ⅞″ coaxial line construction allows higher power operation with ⅞″ connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, ⅜″ connectors; 10 kw peak, 10 watts average.) Features 15 db isolation and 1 db max. insertion loss. VSWR is 1.25 max. based on 2:1 load mismatch; 1.15 max. into matched load. Model 1233: 2.0—4.0 kmc; model 1233-1: 3.0—5.5 kmc; $450. each.

• low power broadband waveguide ferrite isolators



Provide maximum load isolation and minimum insertion loss over full standard waveguide frequency ranges. Extremely useful for maintaining signal source stability and eliminating long line and frequency pulling effects. Front-to-back ratios are the highest available on the market today: C Band—26:1, $250; XN Band—25:1, $225; XB Band—30:1, $235; X Band—30:1, $220.

• high power broadband waveguide ferrite isolators



The only line of high power isolators that covers all of X Band with just two models (8.2-10.0 kmc and 10.0-12.4 kmc), each with front/back ratio of 40:1. Input power rating: 250 kw peak, 300 watts average, achieved through use of special high Curie temperature ferrite materials. VSWR is 1.05 max. with matched load; 1.10 max. with 3:1 mismatch. Only $175 each. Model with same VSWR, 28:1 front/back ratio, 300 kw peak, and 300 watts average, for 7.05-10.0 kmc, $195.

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SERVICE

Recently, one of our friends was telling us that he was anxious to be of service to the federal government. He and a few of his associates had discussed in some detail the problems of society with particular emphasis on our own country. They concluded that service to the government was an ideal goal for people with certain qualifications.

I should point out that our friend is a successful entrepreneur in the microwave industry. He has also spent several years in the academic atmosphere. It is his serious contention that these two qualifications combined will fortify an individual seeking to serve in the purest sense of the word — that, plus the financial independence achieved as a successful business man. He also pointed out that he was busy studying areas in which he might be able to serve.

It was quite obvious that he was serious about his intention. The conversation has since led me to consider the problem and to discuss it with others. It is interesting because to most people, after they have achieved relative financial independence, the next step is retirement.

One thing that I have found out is that this is not a unique thought. There are other people — maybe only a few — who have voiced similar opinions. Having proven themselves in engineering and business, they ask what next?

The idea is not new. Many people in the past have probably done the same. The novel part is the desire to achieve a degree of success in both the academic and business fields, plus financial security, before offering to serve. A man in such a position would be able to serve with maximum efficiency and independence.

How the individual would serve is not too important. There are vast areas that need competent help, both directly and indirectly.

As the government becomes more and more involved in technological and scientific areas, this type of individual becomes a valuable asset to our society. It is such an obvious thing once it is explained that I am a little surprised that more people have not considered doing the same.

True, there are many prominent scientists presently serving the government. I would venture to say, however, in most cases they were asked to serve and not vice versa. This new (?) attitude is both refreshing and exciting. It leads one to think.

Our nation was built and made great on the strength of individuals of this type. It is good to know the breed is not extinct.

Ted Saad

The most compact X-band Magnetron available to provide 200 watts peak power or 20 watts CW

ACTUAL SIZE

What requirements are most important in airborne beacons? High reliability, excellence in package design, efficiency, and the highest obtainable stable output.

It is not a coincidence that Microwave Associates' MA-231 and MA-232 X-band magnetrons have just these features. Our magnetron experience has stressed design of small tubes for high reliability, military airborne applications.

These new tubes, for use at frequencies between 7500 and 10,000 Mc provide the highest available power in an already-proven package . . . compact, rugged, and ideal for beacon applications. They weigh 11 ounces.

For beacon, transponder, airborne navigation, or proximity detection uses . . . there is no smaller, more efficient magnetron.

Individual data sheets on the MA-231 and MA-232 will be sent on request.

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Type*	Freq. Range (Mc)	Peak Power Output (Min.)	Pulse Width (µs)	Duty Cycle Du	Peak dc Anode Voltage eb (kv)	Peak dc Anode Current ib (a)
MA-231A	7500-8800	200 w	1.0	0.05	1.00	0.750
MA-232A	8800-10,000	200 w	1.0	0.05	1.00	0.750
MA-231B	7500-8800	20 w	CW	1.0	0.93	0.055
MA-232B	8800-10,000	20 w	CW	1.0	0.93	0.055

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second international conference on . . . . quantum electronics

Less than two years have passed since the first Quantum Electronics Conference was held. At that time the principal emphasis was on microwave masers with just a few papers discussing the possibilities of optical masers and related phenomena. In this short period the picture has changed so rapidly that at the Second Quantum Electronics Conference, held at Berkeley, California in March, featured many of the papers devoted to problems on optical and infrared masers. The conference, which was sponsored by the Office of Naval Research under the chairmanship of Professor J. R. Singer of the University of California, was an unqualified success.

Optical Masers

The first session, restricted to optical masers, highlighted Professor C. H. Townes as the opening speaker. He reported on the progress in optical masers and predicted several possible new developments which would permit the realization of coherent sources in the far infrared and submillimeter region. He emphasized the importance of such masers as high resolution monochromators for use in basic research. Experiments involving infrared spectroscopy for chemical analysis and more accurate measurements of the velocity of light were discussed.

Townes briefly mentioned the work at Columbia University on the Cesium vapor maser which is optically excited by a helium lamp. This maser follows in principle the scheme originally suggested by Townes and Schawlow in their early paper on optical masers. He also made a brief reference to the use of microwave masers which have now found their way into both radar and communications systems.

He suggested the important role these would have in connection with Project Ozma, which involves the use of a large receiving antenna tuned to the hydrogen line at 21 centimeters expecting to receive signals at this frequency from intelligent life in outer space.

Shortly following him, A. L. Schawlow of the Bell Telephone Laboratories presented a very interesting paper of spectroscopic studies of chromium in magnesium oxide and aluminum oxide. With a high resolution diffraction spectrometer, low temperatures, and use of dilute ruby, structure due to the presence of chromium isotopes was observed. In addition, splitting of the R-lines by stress was demonstrated as well as that due to the Zeeman effect in a magnetic field. Dr. Schawlow also referred to experiments on highly doped ruby in which the ground state is split by the exchange interaction. This transition has been used by I. Wieder and L. R. Sarles of Varian Associates and also by the Bell Telephone group to operate a ruby maser. Stimulated emission in 0.7 per cent Cr^{3+} at 7010A and 7040A was observed.

The papers on actual operating masers were begun by T. H. Maiman of Hughes Research Laboratories, who was responsible for the development of the first ruby maser. He presented the basic principles of the three level optical maser shown in Figure 1 and the theory of stimulated optical emission in such a system. He demonstrated the experimental results which confirmed the analysis.

Two new masers developed at the IBM Research Center were presented by P. P. Sorokin and M. J. Stevenson. The novel feature of these two papers was that a new host material, calcium fluoride, was utilized for the first time. This was doped with a 0.1 percent of Samarium, Sm++ ion, which gave rise to stimulated emission at approximately 2.6 microns. The second utilized trivalent uranium ion in calcium fluoride corresponding to electron transitions in the 5-f shell.

The significant aspect of these two masers was that they involved transitions between four levels rather than three levels, as in the case of the ruby maser. Since there is an energy separation between the two lowest levels at low temperatures, due to the Boltzmann distribution, the upper of these two levels is less populated and consequently

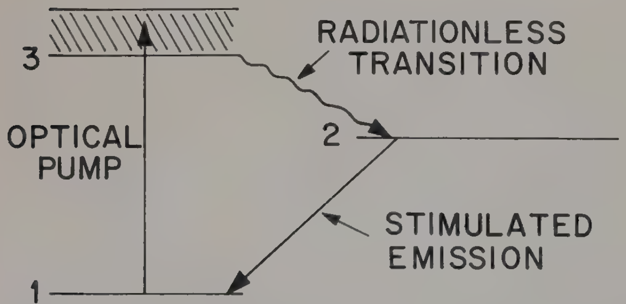

Figure 1 — Energy diagram of a 3-level optical maser, i.e., ruby.

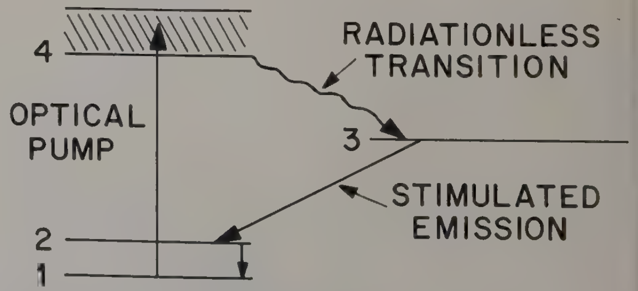

Figure 2 — Energy diagram of a 4-level optical maser, i.e., U+ + + or Sm + + in CaF$_2$.

“ALTHOUGH THE OPTICAL MASER
S NOW A REALITY,
MUCH REMAINS TO BE ACCOMPLISHED.”

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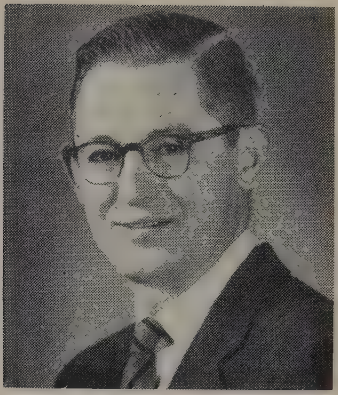

BENJAMIN LAX,* ASSOCIATE EDITOR, *the microwave journal*

he number of electrons to invert the population of state hree relative to two, as shown in Figure 2, is much maller than that required in the ruby maser. Indeed this proved to be the case. It is hoped that such a system can eventually be made to operate on a continuous rather than a pulsed basis, although this has not yet been successfully achieved.

Following this work, some very interesting papers were presented by the people from Bell Telephone Laboratories involving the use of the Samarium maser and the ruby maser. C. G. B. Garrett, W. Kaiser and D. L. Wood showed some interference patterns demonstrating the directional properties of the light beam as obtained from the output of Fabry-Perot interferometer. D. F. Nelson and R. J. Collins presented studies on the time dependence, the monochromaticity, the polarization, spacial coherence, directionality and power output of the emission of the pulse ruby optical maser.

Continuous Gas Maser

Perhaps the most exciting new result presented at this conference was that given by Ali Javan of Bell Telephone Laboratories. He discussed his recent results on the successful operation of a continuous optical maser from a gaseous discharge. Dr. Javan described the careful and methodical investigation conducted by himself and his colleagues, W. P. Bennett and D. R. Herriott, in investigating the properties of a helium-neon mixture in which the metastable excited levels of helium were utilized to transfer energy to an excited state of the argon atom, threby producing electrically a population inversion in the energy states of argon as indicated in Figure 3.

The resultant transitions to a lower state produced emission at 2.1 microns with an energy as high as 50 milliwatts. The source of energy was a ratio frequency discharge which ionized the helium atoms. The helium atom then was excited to a metastable level at approximately 19.8 ev, which then gave up its energy to a neon atom on collision, raising an electron in the latter to one of four excited states slightly lower in energy. The stimulated emission occurs from these states to one of 10 states approximately 19 ev above the ground state. The electrons then fall to the ground state in two steps as indicated.

This maser is rather large in size, 80 inches overall between the reflecting end plates of the interferometer, which are about two inches in diameter. The coherence of the output was demonstrated by the existence of diffraction patterns similar to those obtained from the solid state optical masers.

Optical Properties

A session was devoted to the discussion of the optical spectra of both gasses and solids. Professor Brossell of the

(*Continued on page 14*)

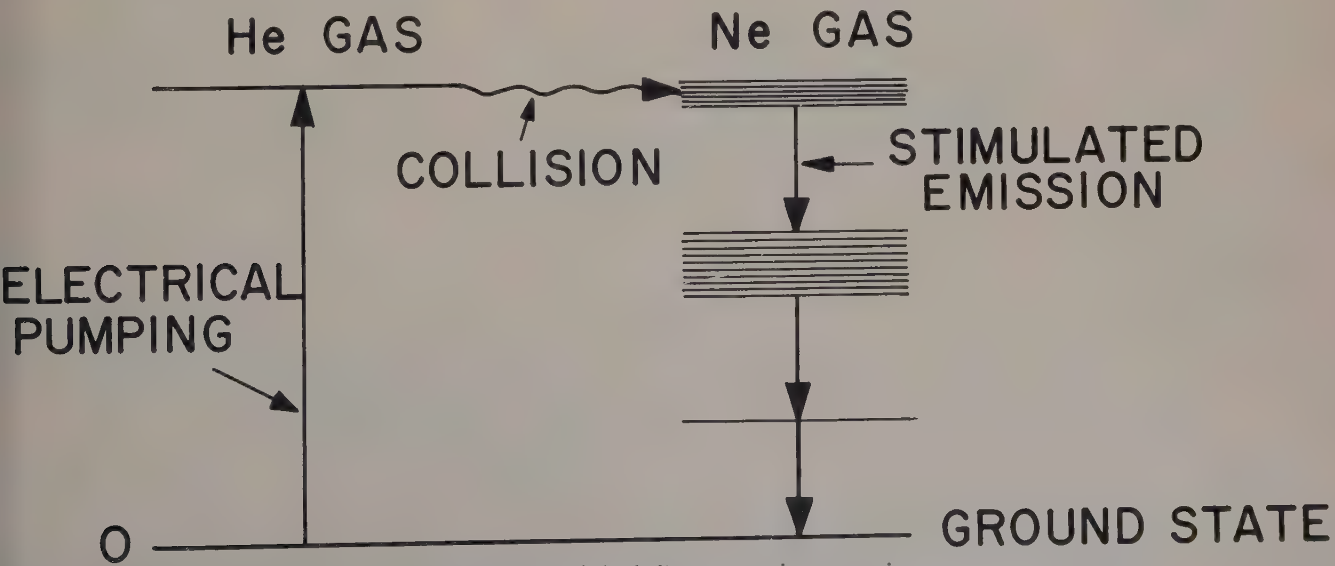

Figure 3 — Energy diagram of the helium-neon mixture continuous gas maser.

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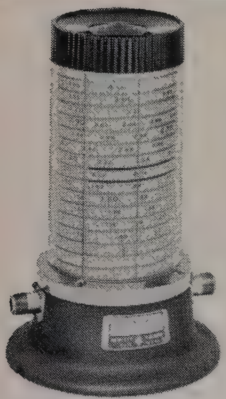
* *Head, Solid State Division, Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology with the joint support of the U.S. Army, Navy and Air Force.*

Here's new convenience, versatility in 1 to 4 GC microwave measurement



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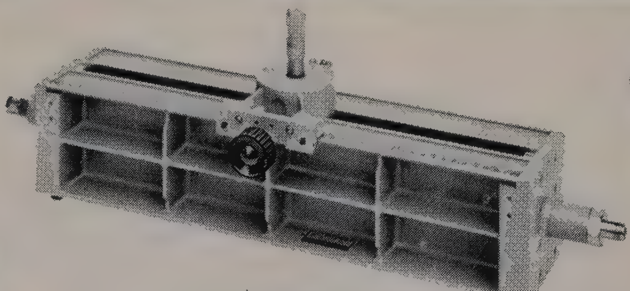
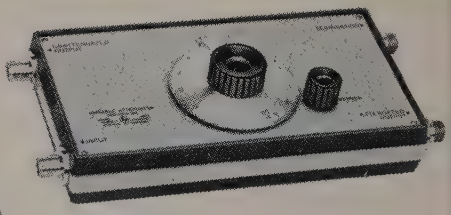
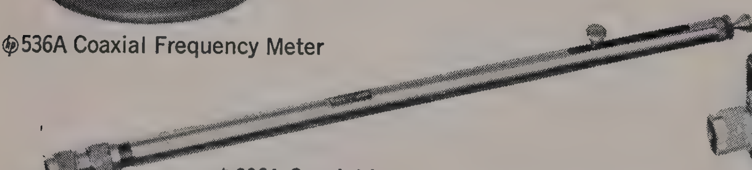


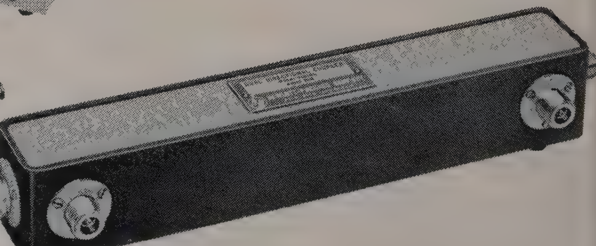
ⓗⓟ872A Coaxial Slide-Screw Tuner



ⓗⓟ393A/394A Variable Attenuators



ⓗⓟ906A Coaxial Load



ⓗⓟ760D/761D Dual Directional Couplers

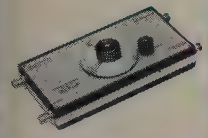
Here are seven new hp coaxial instruments to simplify your microwave work and give you greater measuring flexibility in the important 1-to-4 GC frequency range. Look at the increased versatility of measurements possible with these instruments, each carrying the assurance of quality, versatility, dependability and value which make Hewlett-Packard's one of the world's most widely used lines of microwave instrumentation.

hp 536A Coaxial Frequency Meter

For lab or production use this general-purpose frequency meter is a high resolution, broadband, direct reading instrument. Frequency is read directly in GC with high accuracy over a wide range of environmental conditions. Readability is increased by a long spiral scale calibrated in small frequency increments. The tuning plunger is spring-loaded to eliminate backlash. Smooth tuning and long life result from use of a non-contacting plunger.

Specifications

Frequency Range:	1 to 4 GC
Overall Accuracy:	0.14%
Dial Calibration Accuracy:	0.10%
Max. Temp. Coefficient/° C:	0.0016%
Connectors:	Type N
Dimensions:	9⅛" high x 6" long x 6" deep. 13 pounds
Price:	hp 536A, $500.00

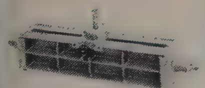


hp 393A/394A Variable Attenuators

Accurate attenuation in high power coaxial systems is provided by these direct-reading, multi-purpose instruments, the hp 393A, 0.5 to 1 GC, and hp 394A, 1 to 2 GC. They are variable attenuators, variable directional couplers and local oscillator mixers. The direct-reading feature eliminates the need for calibration curves, and the attenuators handle up to 200 watts average, depending on line terminations. Two hp 908A low-power coaxial loads (furnished) permit the instruments to attenuate at levels up to 0.5 watt average power.

Specifications

Frequency Range:	hp 393A, 0.5 to 1 GC; hp 394A, 1 to 2 GC
Attenuation or Coupling:	hp 393A, 5 to 120 db, hp 394A, 6 to 120 db; both continuously variable
Absolute Accuracy:	Within ± 1 db or 1% of dial (hp 393A), ± 1.25 db or 2% of dial (hp 394A), whichever is greater. (With matched generator and load)
Nominal Impedance:	50 ohms
SWR:	< 2.5:1, 5 - 10 db attenuation; < 1.5:1, 10 - 30 db; < 1.2:1, 30 - 120 db (hp 393A); < 1.4:1, 30 - 120 db (hp 394A)
Directivity:	Greater than 15 db (hp 393A), or 10 db (hp 394A), 10 to 40 db attenuation with loads of less than 1.05:1 SWR
Maximum Voltage:	500 v peak
Connectors:	Type N
Dimensions:	5½" x 12" x 2¾"
Price:	hp 393A, $420.00; hp 394A, $420.00



hp 872A Coaxial Slide-Screw Tuner

With the hp 872A Coaxial Slide-Screw Tuner, insertion of the precision probe carriage into a specially developed slab line is quickly and easily varied with a micrometer drive, and position along the line may be read directly on a recessed scale. Probe travel is at least ½ wavelength at 0.5 GC so that any phase reflection may be compensated. Logging penetration and position of the probe makes repetition of settings simple, and the probe can be withdrawn so that no correction is applied.

Specifications

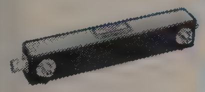
Frequency Range:	0.5 to 4 GC
Correctable SWR:	10
Insertion Loss at Max. Correctable SWR:	1 db or less
Characteristic Impedance:	50 ohms
Connectors:	Type N
Dimensions:	27" x 6" x 5"
Price:	hp 872A, $525.00

hp 906A Coaxial Load

This sliding coaxial termination is a movable, low reflection load for terminating 50-ohm systems in their characteristic impedance. The load moves at least ½ wavelength at its lowest rated frequency. It features a movable center conductor which insures proper seating in the mating conductor. Included are adapters for Type N connectors, plus storage case.

Specifications

Frequency Range:	1 to 12.4 GC
Load SWR:	Less than 1.05
Power Rating:	1 watt
Travel:	Greater than ½ wavelength at 1 GC
Dimensions:	31" long. 2 lbs.
Price:	hp 906A, $250.00



hp 760D/761D Dual Directional Couplers

New hp 760D/761D Dual Directional Couplers, two-octave vhf-uhf instruments, are especially useful for power monitoring, mixing and power sampling with tightly controlled coupling. High directivity and flat frequency response make them ideal for reflectometer systems. Power capacity is 50 watts cw and 10 kw peak.

Specifications

	Model 760D	Model 761D
Frequency Range:	250 - 1000 MC	1 - 4 GC
Mean Coupling:	20 ± ½ db	20 ± ½ db
Coupling Variation:	± ½ db	± ½ db
Directivity (Minimum):	35 db	30 db
Primary SWR (Maximum):	1.20	1.25
Secondary SWR (Maximum):	1.25	1.30
Connectors:	Type N	Type N
Price:	$200.00	$185.00

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(*Continued from page 11*)

Ecole Normale Superieure, Universite de Paris, talked about the progress in the optical pumping in gases that he and his colleagues have pioneered in France. Brossell reviewed the principle of the early experiments of optical pumping in mercury isotopes 209, 199 and 204. He described the use of transient methods for measuring relaxation times including relaxation due to collision with the walls.

An exposition of the quantum theory related to these experiments was presented by Dr. Cohen-Tannoudju, also of the Ecole Normale Superieure, Universite de Paris. His analysis predicted frequency shifts of the magnetic resonance lines under the influence of optical excitation.

A comprehensive investigation of the Brossell-Bitter type of experiment in which double resonance is observed by modulating the fluorescent light with microwave and rf frequency was given by Dr. G. W. Series of the Clarendon Laboratory in which he presented the theory and experiment of different line shapes obtained under a variety of conditions of excitation.

Professor Low of the Hebrew University of Jerusalem discussed theoretical and experimental results of the energy levels of rare earth magnetic ions in the crystal fields of solids. He presented techniques used for calculating the energy levels in crystal fields of high symmetry such as the cubic field and showed absorption and fluorescent spectra under these conditions. His experimental data for CaF_2 showed a variation of line width with temperature being a factor of about seven from zero degrees on up to 300 degrees.

Experiments closely related were presented by Professor Dieke of the Johns Hopkins University in which he presented detailed spectra of a large number of magnetic ions of particular interest for optical masers. He presented data of the energy levels of the trivalent rare earth ions in various host crystals, demonstrating the effect of different crystalline field symmetries upon the levels. He also showed the effect of concentration of magnetic ions on line width and also the effect of magnetic fields in the Zeeman spectra of these levels.

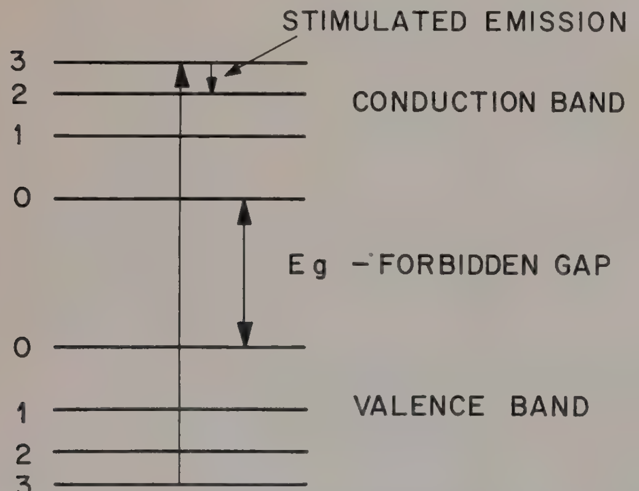

Figure 4 — Energy levels of the semiconducting cyclotron resonance maser.

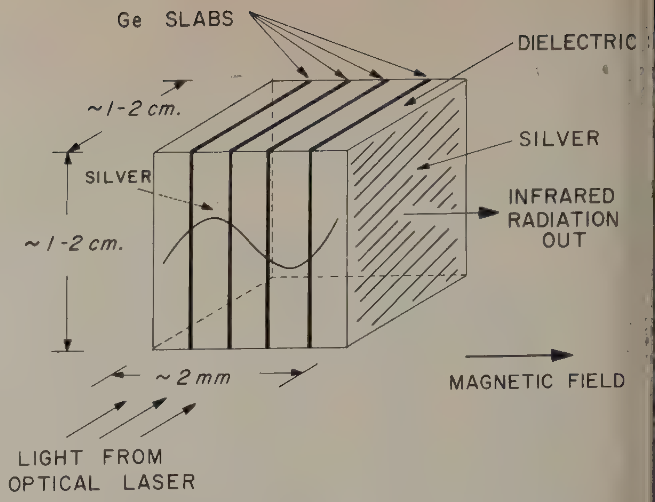

Figure 5 — Details of the design of a far infrared cyclotron resonance maser. (After B. Lax).

Semiconductor Masers

Following the papers presented on optical masers, two proposals for infrared masers were presented. The first was by B. Lax of Lincoln Laboratory who showed that a cyclotron resonance maser in such semiconductors as germanium and related intermetallic compounds was now theoretically possible for two reasons. First, optical masers such as the ruby or the uranium maser can be utilized as efficient sources for pumping of the interband transitions between magnetic levels of the valence band to those of the conduction band as shown in Figure 4. Thus 1000 watts of peak power is sufficient to create an inverted population of the cyclotron resonance level, three relative to two, such that induced emission in a resonant structure in the presence of a magnetic field between these adjacent levels would overcome the losses to give stimulated emission in the far infrared and submillimeter region of the spectrum.

The structure would have the appearance shown in Figure 5, in which many slabs of germanium or equivalent would be excited by the optical source and then stimulated by the self-excited coherent far infrared radiation which penetrates the slabs but is multiply reflected by the silver-plated ends. The importance of this type of maser is that it will be tunable by varying the magnetic field and would provide a source of energy perhaps of the order of milliwatts in the region of the electromagnetic spectrum which is energy starved.

The second proposal was made by Dr. N. G. Basov of the Lebedev Institute in Moscow in which he indicated that negative resistance was obtained by optically pumping into silicon at low temperatures photon energy equal to the energy gap plus the phonon energy as the pumping source. A signal energy at the same time was fed in at a smaller photon energy equal to the energy gap minus the phonon energy which presumably induced emission to give a negative resistance of the photoconduction in the silicon. Lax indicated that such a system has been tried at Lincoln Laboratory by D. Edwards to build an infrared maser using pulsed light, but so far it has not been successful.

Professor Aigrain and coworkers at the Ecole Norma Superieure, Paris, are attempting to make such a maser work in germanium in which they utilize electrical pump g in a P-N-I-P structure so that electrons of the order of 0^{17} to 10^{18} can be excited into the conduction band and imulated emission from an interferometer consisting of silvered parallel sides which would give emission in the frared.

icrowaves and Millimeters

The most exciting progress in microwave masers was escribed by D. Kleppner of Harvard who discussed the eam type of maser analogous to the first ammonia maser, xcept this time the transition for the induced emission vas due to the hyperfine structure of the hydrogen atom t 1420 megacycles. The mechanical Q of the system was ncreased by putting a paraffin coating on the walls of the nicrowave cavity thereby providing a longer effective fetime for the hyperfine transition which has a relatively ow transition probability. The actual time, before detruction by colliding on a treated wall of the cavity, is pproximately 0.3 second. The schematic of the maser is hown in Figure 6. The stability of such a maser may be s high as one part in 10^{12}, somewhat higher than that of ny existing maser today.

An operational 21 cm ruby maser at the Harvard Colege Observatory was described by Jelley and Cooper with n overall system noise temperature of 97±5°K. This as been used for radio astronomical observations of the ydrogen line with a significant overall improvement over he conventional radiometer system utilized heretofore.

Millimeter generation and detection is not a new subect and has been discussed on several occasions during the ast decade. However, several new developments which vere covered at the meeting are worthy of attention.

S. Foner of Lincoln Laboratory reviewed the status of nillimeter masers. He mentioned briefly the ruby maser vith a pulsed magnetic field, which was reported at the ast conference, and has been operated up to 75 kMc.

The new results of greater importance was the coninuous millimeter maser using Fe^{3+} in rutile TiO_2 which e developed with his colleagues, Momo, Thaxter, Heller nd White. This maser when pumped with a four millimeter klystron and recently with a two millimeter carcinaron has been operated at frequencies from 26 kMcps to 6 kMcps. The tuning is achieved by rotating the magetic field relative to the crystal axes. The resonant cavity as many operating modes within this frequency range because the dielectric constant of the rutile is high and anisotropic and it fills the entire resonant structure.

A second interesting development was presented by J. S. Thorp of the Radar Research Establishment, Malvern, England, who discussed an 8 millimeter ruby maser using adiabatic rapid passage both as an amplifier and as an oscillator.

Submillimeter

The submillimeter region, which has been a difficult region of the electromagnetic spectrum, received some attention. H. A. Gebbie of the National Physical Laboratory, Teddington, England, described the novel design and operation of a Michelson interferometer capable of operating from 50 to 1000 microns. By using computer techniques for taking the Fourier transform of the spectral data he can achieve one to two orders of increase in resolution over the grating spectrometers used at present.

Another approach to the solution of the submillimeter problem was offered by Professor Coleman of Illinois University. He proposes to use Cerenkov radiation from a bunched electron beam which is accelerated at relativistic velocities through a dielectric, ferrite or a plasma.

Still in another vein, Professor Burstein of the University of Pennsylvania described a new quantum detector which he, B. N. Taylor and D. N. Langenberg are developing for the submillimeter region. The detector involves the use of superconducting tunnel devices developed by Giaever at General Electric. The tunnel current would be sensitive to submillimeter quanta since the energy gap in superconductors is small enough to allow the creation of carriers for tunneling across the junction.

Oscillation Spikes of Optical Masers

Several theoretical papers dealing with the modulated output of optical masers elucidated the pulsating characteristics often found in these devices. The first of these presented by J. R. Singer and S. Wang calculated the theoretical output versus time of such a maser. This is shown in Figure 7.

The analysis indicated that below a threshhold power of the optical pump the output of the master is amplitude modulated because the inverted level is depopulated by fast rate of coherent induced emission. Above a threshhold of the pump power the oscillations disappear since

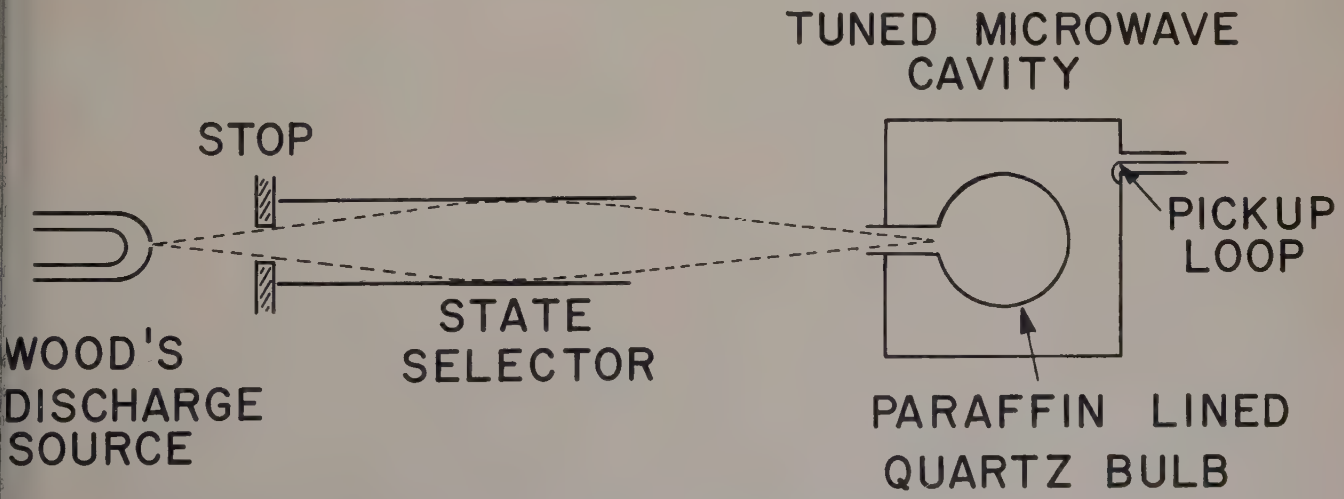

Figure 6 — Schematic of the 21 cm hydrogen maser. (After H. M. Goldenberg, D. Kleppner and N. F. Ramsey).

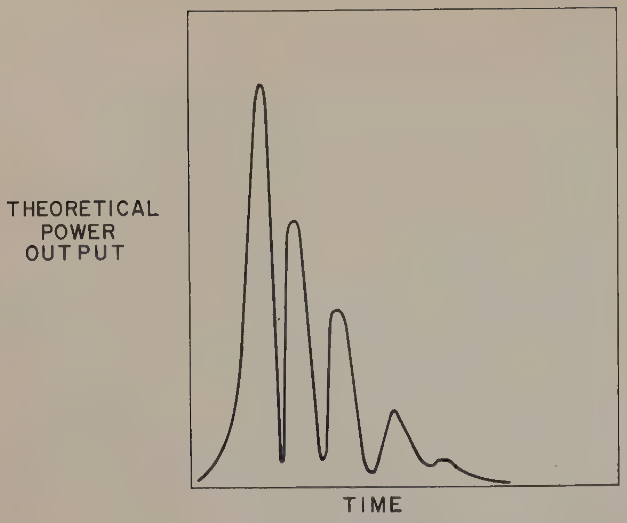

Figure 7 — Pulsating output of a maser. Theory and experiment agree. (After J. R. Singer and S. Wang).

the inverted level is populated at a greater rate than that which depopulates it by induced emission.

W. G. Wagner and G. Birnbaum analyzed the power distribution among various modes in a multimode resonator in a steady state operation as a function of pumping power. They also examined the time dependent behavior as well.

Another analysis of the oscillation spikes in a multimode laser by H. Statz, C. Luck, C. Shafer and M. Ciftan of Raytheon indicated that the initial spikes are due to one set of modes which go unstable during the pump pulse. This emission pulse depletes excited ions in one region of the laser. The second pulse involves another set of modes which depletes excited ions in another region, and so on. Experimental probing by photodetectors confirmed this prediction and indicated an obstacle to achieving CW operation of the laser.

A useful aspect of this phenomenon was proposed by R. W. Hellwarth of the Hughes Research Laboratories who suggested that by controlling the reflectivity of the end plates of the resonant interferometer, the power output of the pulse output can be enhanced. If the reflectivity initially is low, no induced emission is possible allowing the inverted population of the excited ions to pile up. Then when the reflectivity is suddenly increased to make the interferometer operative resonantly, the energy is released by induced emission considerably in excess of that in the usual operation. The pulsed output may reach the megawatt region at the peak of the delayed pulsation.

Modulation and Mixing of Light

The possibility of modulating light was discussed by P. S. Pershan of Harvard. He considered various schemes for achieving this at microwave frequencies. Electro-optic effects in solids appear to be most promising. The investigations have been carried out in KH_2PO_4. Magnetic modulation in paramagnetic or ferrimagnetic substances was also considered.

A method of r.f. modulation of light in optically pumped spin system as in Cs and Rb vapor was discussed by A. L. Bloom and W. E. Bell of Varian Associates. They also showed how the spin system can be used to mix two radio frequencies. The phenomenon can be used as a detector of modulated light. A. F. Forrester of Electro-Optical Systems also considered mixing of light waves by a photoelectric process to provide superhetrodyning techniques similar to those at radio frequencies.

An interesting application of the modulation of light by microwaves was given by S. Geschwind, R. J Collins and A. L. Shawlow of Bell Telephone Laboratories who described an experiment in which optical detection of paramagnetic resonance of the excited states in ruby was employed. Monitoring of the light instead of the microwave power increased the sensitivity of the paramagnetic resonance observations by several orders of magnitude.

Optical Sources for Masers

Professor Edgerton of M.I.T. described the design of a Xenon flash lamp made of quartz or vycor which is excited by a large capacitor bank and is particularly usefu for pumping of optical masers. S. A. Colgate and A. W. Trivelpiece of the University of California proposed the use of dynamic pinch as a high intensity light source fo pumping an optical maser. By choosing the appropriate impurities as much as 10^8 watts in plasma could be delivered in optical energy in a pulse of the order of 10^{-} seconds.

Optical Resonators and Waveguides

The theoretical and experimental aspects of mode configurations in maser interferometers and waveguides received some attention. A. G. Fox and T. Li of Bell Telephone Laboratories presented the results of the diffraction of electromagnetic waves in a Fabry-Perot interferometer when used as optical resonators.

The mode configuration of the low loss modes and fiel configuration for different mirror geometries and modes were presented. They showed that in an oscillating mase the lowest order mode should dominate if the mirro spacing is appropriate for resonance. They also showe the a confocal spherical system would have lower losses than plane mirrors. G. D. Boyd of Bell Telephone Laboratory gave a detailed analysis of such a system. He pointe out that such a system had diffraction losses an order o magnitude below that of plane mirrors. The optica alignment of the two reflectors is less critical. The pum power required by a confocal resonator should be lowe than that of the plane parallel resonator.

One of the interesting highlights of the conference wa a paper given by E. Snitzer of the American Optical Company who discussed the electromagnetic modes in optica dielectric modes in glass fibers. These were 0.1 to 2 microns thick and operate on total internal reflection Beautiful mode patterns were displayed on photographi slides showing the near and far field projections of ligh from the ends of the fibers which support these modes.

Conclusion

The conference featured the significant advances which have been made in the maser field during the last two years. Although the optical maser is now a reality, much remains to be accomplished. The fundamental investigations must be extended to new materials and greater understanding of the existing phenomena is needed.

One of the objectives will be to achieve a CW soli state optical maser. Greater power output for application is another desirable aim. Finally, it is extremely desirabl to extend the maser techniques to the submillimeter and far infrared regions of the spectrum where sources o even modest energy would be highly welcome.

New millimeter wave FERRITE COMPONENTS . . . The new FERIMAT tunable isolator is, like most TRG ferrite components, the first of its kind. The only one of its kind. Available nowhere else. Yet, like all other advanced TRG components, it is available on short delivery. TRG has made this kind of pioneering a habit. Matter of fact, there is today only one source for a complete line of millimeter wave components of all types, covering the entire 26.5 to 140 kmc. region. That source is TRG. Whatever your problem — a component, or complete systems development . . . TRG has more of everything it takes . . including experience . . . to place the answers right in the palm of your hands. Please write for Catalog 260A today.

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FREQUENCY RANGE — KMC	A-band 26.5–40	V-band 50–75	E-band 60–90	F-band 90–140	TYPICAL PERFORMANCE FOR A, V and E BANDS	REMARKS
FERIMAT Tunable Isolator	A100	V100	E100	F100*	VSWR 1.25 max. — Loss 1.5db max. — Isolation 20db min.	Operates over full waveguide frequency range
Isolator	A110	V110	E110	F110*	VSWR 1.25—Loss .7db—Isolation 17db min., 25db at center	Bandwidth: 6% A-band, 3% V and E-band. Low power Faraday rotation type isolator
On-off Switch or Variable Attenuator	A120	V120	E120	F120*	VSWR 1.25 — Loss 1.5db— Isolation 50db	Low power — approx. 150ma switching current 3μ sec. rise time
Modulator	A130	V130	E130	F130*	4% Band — VSWR 1.25 — Loss: on 1.5db — off 30db	Normally closed — approx. 150 ma switching current 3μ sec. rise time
Reciprocal Switch	A140	V140	E140	F140*	3% Band — VSWR 1.25 — Loss 1db — Isolation 20db	High power — approx. 150ma switching current 3μ sec. rise time
Y-Circulator	A150	V150	E150	F150*	VSWR 1.25 — Loss 2db — Isolation 35db	Three port spot tuned for narrow band operation
Four Port Circulator	A160	V160	E160	F160*	3% Band — VSWR 1.3 — Loss 1db — Isolation 20db	Utilizes two dual mode transducers and Faraday rotator

*Under development

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DR. PETER LACY

Vice President

WILTRON

Palo Alto, California

By WILLIAM HESTER

Dr. Peter Lacy is one of the founders and Vice President of Wiltron, a comparatively new electronics firm in Palo Alto, California. He has followed a familiar path: tinkerer and radio amateur in high school, engineering student, officer in the military service, graduate student, engineer, and finally entrepreneur.

Pete was born and raised in Jacksonville, Florida. He became interested in radio at an early age and had a ham license, station W4DIQ, when he was fourteen. Radio and scouting were his principal hobbies in high school, as it turned out, a fortuitous combination. Some of the boys who had been in the Scouts had jobs at the radio station at the University of Florida. As vacancies occurred, they were filled from the ranks of ex-Scouts, and this precedent was continued. In this way Pete got his turn at a job as engineer at the University radio station.

In 1942, Peter Lacy received his B.S. in E.E. from the University of Florida. During his four years there, he worked as an engineer and finally chief engineer of the state-owned radio station, did consulting in radio engineering, and built and installed some police radio stations. He also managed to study. The University had some projects in the new field of sferics, hurricane location by radio. Each year during the comparatively short hurricane season, Pete and his fellow-classmates working on the project would make measurements and collect data.

Besides the University station at Gainesville, Florida, there was one at San Juan, Puerto Rico and one at Ottawa, Canada. After the hurricane season, they assembled the data from the three stations and spent the rest of the school year triangulating and analyzing the results.

Sferics utilized low-frequency radio signals and, consequently, the best data could be taken only at night. To complicate matters, it was impossible to drive during the hurricanes, so Pete and his friends had to walk to the station. Many nights he dodged trees and unidentified flying objects on his way to the station.

After graduation, Pete remained at the University teaching a senior course in radar engineering and an electronics course in the new Officers' Training Program for six months.

The war interrupted his teaching and plans for graduate education. Early in 1943, Pete entered the Navy as an Ensign. He was in the service for three years and finally was discharged as a Lieutenant. Half his time was spent in the Pacific Theater of Operations where he worked on Electronic Countermeasures, the remaining one and a half years in Washington.

In the Capital, Ensign Lacy worked in an office under Captain William Finch and Commander Gerald Gross. Captain Finch was one of the early workers in facsimile. He had also been called in by the U.S. Senate to investigate and help reorganize the Federal Communications Commission. Commander Gross is now head of international radio affairs at Geneva.

While at Washington, Ensign Lacy had the responsibility of the Navy's transmitter portion of the countermeasures program at Harvard's Radio Research Laboratory. This program was headed by Frederick Terman, now Vice President and Provost of Stanford University.

It was at RRL that Pete met a large group of Stanford alumni including Mike Vellard (now Head of Stanford's Propagation Laboratory) and Stan Kaisel and John Granger, both of whom now head new electronics companies. Pete was so impressed with the Stanford men that he decided to continue his education there, as soon as the war was over.

In 1946, Pete began studying for his advanced degrees at Stanford. He went to Professor Edward Ginzton, then assistant director of Hansen Laboratory, looking for some sort of research job. Professor Ginzton handed Pete an article by D. O. North on noise in vacuum tubes and asked him to read it in half an hour and tell him what he thought of it. Pete's answers must have been satisfactory, r Professor Ginzton offered him a job to do the same ing at microwave frequencies. The salary was $100 month for part-time work. In addition Pete received 5 a month from the Veterans' Administration. The VA o paid tuition.

In 1948 he won a $200 a month fellowship from Sper-. "And it was all tax-free," he recalls.

He received his M.S. degree in 1947 and completed urse work for his doctorate in 1949. He did his Ph.D. search under Professors Ginzton and Chodorow and rote his thesis on noise in electron beams at microwave equencies. He became Dr. Lacy in 1952.

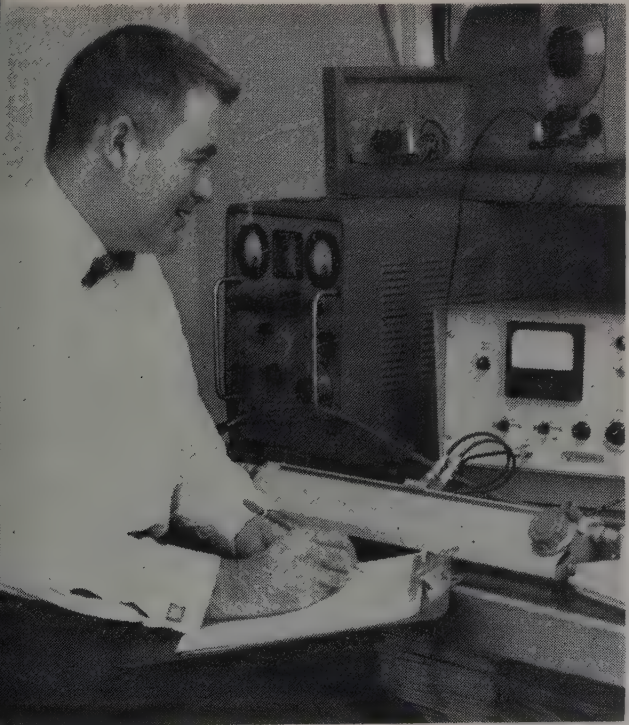
After completing his course work in 1949, Pete worked rt-time as a consultant at Varian Associates on noise in icrowave tubes. Although his salary was higher than it d ever been up to that time, he now had to pay taxes, d his net was less than it had been during his school ars.

Pete was beginning to lose interest in tube work and, the time approached when he would be through with all hool work, he began to consider other branches of elec-onics for his career. He narrowed the field down to stems work with Simon Ramo or instrumentation. But stems work meant going to the Los Angeles area. Pete referred Palo Alto and, in 1950, chose instrumentation at lewlett-Packard, where he remained for ten years.

While at H-P, he became especially interested in the xtreme wide-band properties of TWT's, an interest hich he hopes to exploit at Wiltron. When he and his wo associates left H-P to form their own company, they id so with the sincere good wishes of their former osses. Both Hewlett and Packard encourage engineers go into business for themselves, although as Pete says, they make it so pleasant working there that it's hard to ave."

Wiltron is still too young a company to have made a mark in the electronics community. Pete's associates are William Jarvis, who is President, and Duane Dunwoodie, who is Secretary and Director of Product Development. All three are busy writing proposals and doing much of their own engineering development in microwave and fast pulse instrumentation. By the spring of 1961, they hope to market their first proprietary product, an instrument for testing high speed transistors and diodes. To augment their staff, they hire students on a part-time basis.

Sheet metal shop at Wiltron being used by Dr. Lacy and Bill Jarvis (right), co-founder and president.



r. Lacy records reading from a Wiltron microwave phase meter.

Dr. Lacy is a Senior Member of the IRE. He first joined as a student member while he was an undergraduate at the University of Florida and has been active in the organization ever since. When the San Francisco Chapter of the Professional Group on Microwave Theory and Techniques was formed in 1956, Dr. Lacy was one of the Charter members. He was Chairman of the chapter in 1958-1959. In 1959-1960, he was treasurer of the San Francisco section of the IRE, and he is now secretary. When Kiyo Tomiyasu was editor of the PGMTT Transactions, Dr. Lacy served as a member of the Editorial Staff.

Pete is still interested in the outdoor life he learned as a Boy Scout and his chief hobbies are hiking, camping, and fishing. Five young children keep him and his wife, Susan, too busy to pursue hobbies very seriously, but Mrs. Lacy manages to find time to study singing. The children are still too young to play with radio or show any bent toward science. Undoubtedly, Pete will have them dissecting radio sets as soon as they are old enough, but in the meantime he is participating in the Berg Foundation seminars at the local high school in Redwood City, lending a helping hand to budding scientists.

The story of Pete Lacy is not unusual. It is the story of a typical microwave engineer and could be almost any one of us. The war interrupted studies, but military service broadened horizons. After the war, our wider interests led us into fields and places we might never have considered otherwise. In many cases Government support made graduate study possible and paved the way for the start of many electronics enterprises.

Industry News

RANTEC EMBARKS UPON THREE YEAR EXPANSION PROGRAM

A three-year expansion program including immediate construction of a new engineering and administration building was announced by the Rantec Corp., Calabasas, Cal., which also revealed current sales running in excess of $2 million annually.

Rantec has contracted with architect Charles Luckman to prepare a complete master plan for an industrial complex to include future building densities, parking plans and analysis of future space requirements.

Current backlog and projected sales for the firm indicate an annual rate of $3 million will be reached by the end of 1961, representing an increase of over 50 percent for the firm's microwave RF and antenna products.

To meet current growth, Rantec's manufacturing facility has been expanded to include aluminum dip brazing, precious metal plating, additional precision pantograph milling, and other special machines for microwave and RF fabrication and inspection.

— *m w j* —

PAGANELLI TO HEAD G.E.'s NEW SYSTEMS OPERATION

A new Systems Operation has been established in the General Electric Company's Heavy Military Electronics Department, Syracuse, N.Y., to keep pace with rapidly changing customer needs and technologies in the missile and space age, it has been announced by Robert J. Brown, Department General Manager.

Thomas I. Paganelli, Manager of the Department's Missile Detection Systems Section, has been named to head the new Systems Operation which will consolidate the Company's vast management skills and technical know-how in surface-based surveillance systems, under-sea warfare systems and aerospace defensive systems under one organization.

Mr. Paganelli has been head of the Missile Detection Systems Section since January, 1957. In his role he has been responsible for directing the General Electric Company's participation in several major defense projects such as the AN/FPS-17 radar systems, the Air Force's Experimental Radar Station on Trinidad, W. I., and the Surveillance Radar Sub-Systems for the Ballistic Missile Early Warning System (BMEWS) station at Thule, Greenland and Clear, Alaska.

— *m w j* —

LIGHT, FLEXIBLE ANTENNA DEVELOPED BY SYLVANIA

A new type of antenna composed of a lightweight, rigid foam reflector and an antenna positioning device which can move the reflector through any angle of azimuth and elevation has been developed for the U.S. Army by the Electronic Defense Laboratories (EDL) of Sylvania Electric Products Inc., Mountain View, Cal.

Jesse R. Lien, General Manager of Sylvania's Mountain View Operations, said the equipment is less expensive, stronger, lighter and easier to fabricate than conventional antennas now in existence.

The antenna, developed under contract with the U.S. Army Signal Corps, could have application in satellite communications. Because of the extremely accurate surface of the reflector, it can also be used in the rapidly growing field of radar and radio astronomy.

The Sylvania-designed antenna has a convex, cellular reflector which reduces wind drag by as much as two-thirds. In addition, there is considerable weight reduction. A conventional, metallic 60-foot reflector can weigh 15 tons or more. The same size antenna, utilizing the Sylvania design, will weigh only three tons.

— *m w j* —

(*Continued on page 24*)

MEC *Reports o*

S, C and X-Band, Metal-Ceramic, PPM Focused, Magnetically Shielded, 10 mw Output and 30 db Gain with Maximum Broadband Noise Figure of 10 db.

Typical of MEC's advanced family of metal ceramic low noise traveling-wave tubes is the new M2105. Rugged and reliable, this tube is the result of engineering skill and manufacturing care appropriately combined to form a production tube with truly reproducible characteristics.

Shielding of the tube and its focusing structure, an advantage of the PPM format, eliminates the effect of stray magnetic fields and permits use of tubes in close proximity to magnetic materials or to each other. Elimination of the focusing solenoid and power supply reduces power consumption to less than 3 watts, including heaters, and does away with auxiliary cooling.

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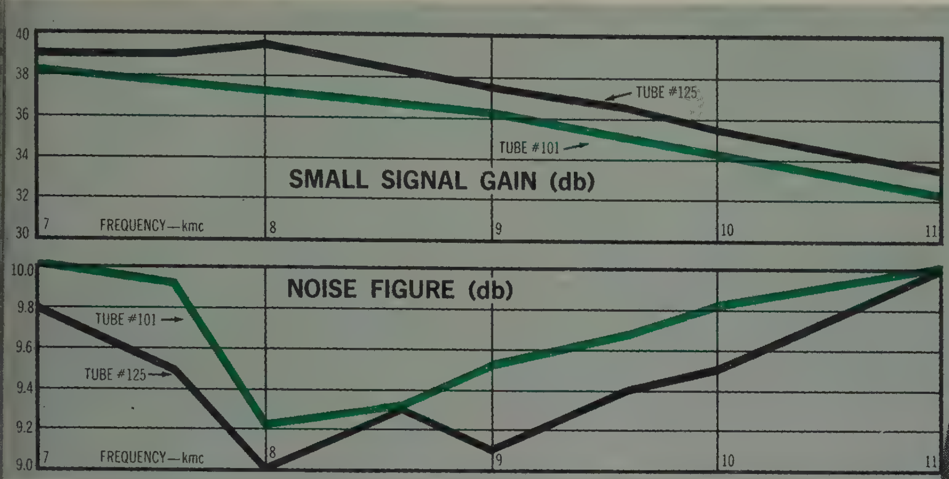
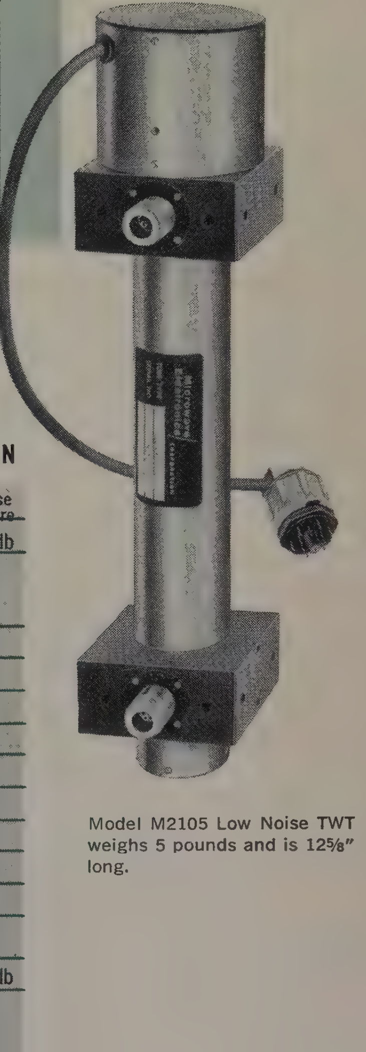
ow Noise TWT's with PPM Focusing



REPEATABILITY MEANS RELIABILITY.
Notice how closely the small signal gain and noise figure characteristics for the first M2105 (#101) compare with those of the last member in the first lot (#125).



Model M2105 Low Noise TWT weighs 5 pounds and is 12⅝" long.

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l-ceramic construction gives
tubes a headstart on reliability.
are evacuated at higher temper-
s (650°C), producing a higher
um and cleaner environment for
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ently rugged, they provide supe-
performance over environmental
mes. (The M2105 withstands
shock and 15 g vibration between
1 2000 cycles with no degradation
rformance. Temperature compen-
n work is now being completed.)

C construction features also in-
e a stacked ceramic gun and a
k rigidly supported by three
mic rods. Critical turn spacing is
rately maintained to assure uni-
gain characteristics from tube-
be. The tube can be operated in
position without change in char-
istics.

TYPICAL LOW NOISE TWT TUBES IN PRODUCTION

PPM FOCUSED TUBES	Frequency Range	Small Signal Gain	Saturation Power	Noise Figure
M2103 Series (Family)	2 - 4 kmc	30 db	10 mw	10 db
	(over 0.5 kmc portion of the band)	30	10	8
	2.3 - 4.4	30	10	10
	2 - 4	30	10	15
M2112 Series	4 - 8	30	10	10
	4.3 - 7.4	30	10	10
	4 - 8	30	10	15
M2105 Series	7 - 11	30	10	10
	7 - 11	30	10	15
	8 - 12.4	30	10	15
M2114	12.4 - 18	30	5	14
SOLENOID FOCUSED TUBES				
M2103 Series	2.0 - 4.0 kmc	30 db	5 mw	8 db
	(over 0.5 kmc portion of the band)	30	5	6
M2107	4.0 - 8.0	30	5	10
M2101 Series	7.0 - 11.0	30	10	9
M2114	12.4 - 18.0	30	5	12

MEC's new short form catalog with complete information on our production engineered line of traveling-wave tubes is available now. In addition to low noise types, the catalog covers medium and low power, serrodyne, and special purpose tubes. For your free copy, call your nearest MEC engineering representative or write to us.

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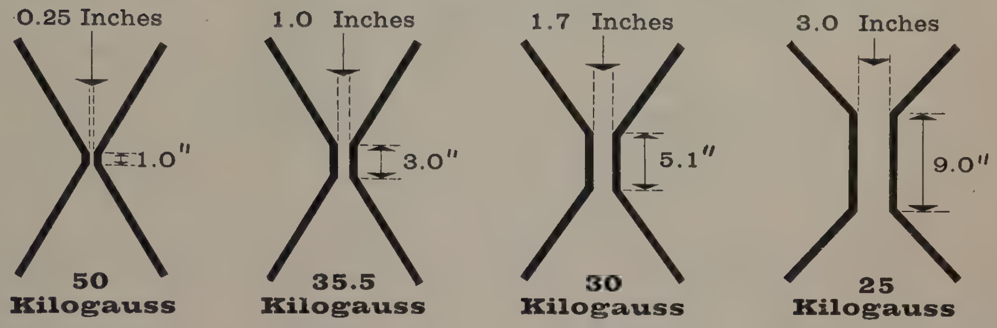
Circle Reader Service Card 8

New High Performance 22" Magnet System from Va

UP TO 50 KG



The achievement—an extension of Varian performance

Highly homogeneous and stable magnetic fields at previously unavailable intensities up to 50 KG are made possible by Varian's new V-3100/V-2400 electromagnet/power supply system. The Key: uncompromising design standards and Varian's traditional painstaking care. This performance is delivered with only modest power and cooling requirements through integrated *system design.* And a high degree of usefulness has been attained without sacrificing performance capabilities:

Alignment of magnetic fields in most specified air gaps is assured by Varian *nuclear-magnetic-resonance* techniques.

Stability of one part in 10^5 against ± 10% line voltage change is achieved by the 40 KW regulated power supply. Optimum regulation against slow *and* fast line changes is accomplished.

Engineered feature by feature for maximum usefulness

In addition to the basic characteristics enumerated, the V-3100/V-2400 system incorporates both conventional and outstanding new design features:

- Massive yoke and 22" diameter pole pieces allow steep pole tapering to achieve extremely high fields.
- Magnetic field may be rotated 225° about the vertical axis; field polarity is reversible by switch circuit.
- Air gap accessibility is assured by the 8" coil separation and 45° yoke angle. A 1"-diameter axial hole is provided through yoke and pole pieces permitting sample irradiation when special axial-hole pole caps are used. Air gap is 36⅝" above bottom of magnet base.
- Economy of operation, achieved by system design, is shown by low input requirements: a nominal 45.5 KW of power (3-phase, 480V/60 cps or 380V/50 cps) and cooling water at 20 gpm—60 psi differential pressure.
- Compact, all-transistorized power supply stands at convenient operating height, and rests on only 3′ x 3′ of floor space.
- System is completely protected by safety interlocks.
- Interchangeable pole caps and adapter plates, and a field-sweep system, are optional at extra cost.
- World-wide field engineering service is available at all times from Varian.

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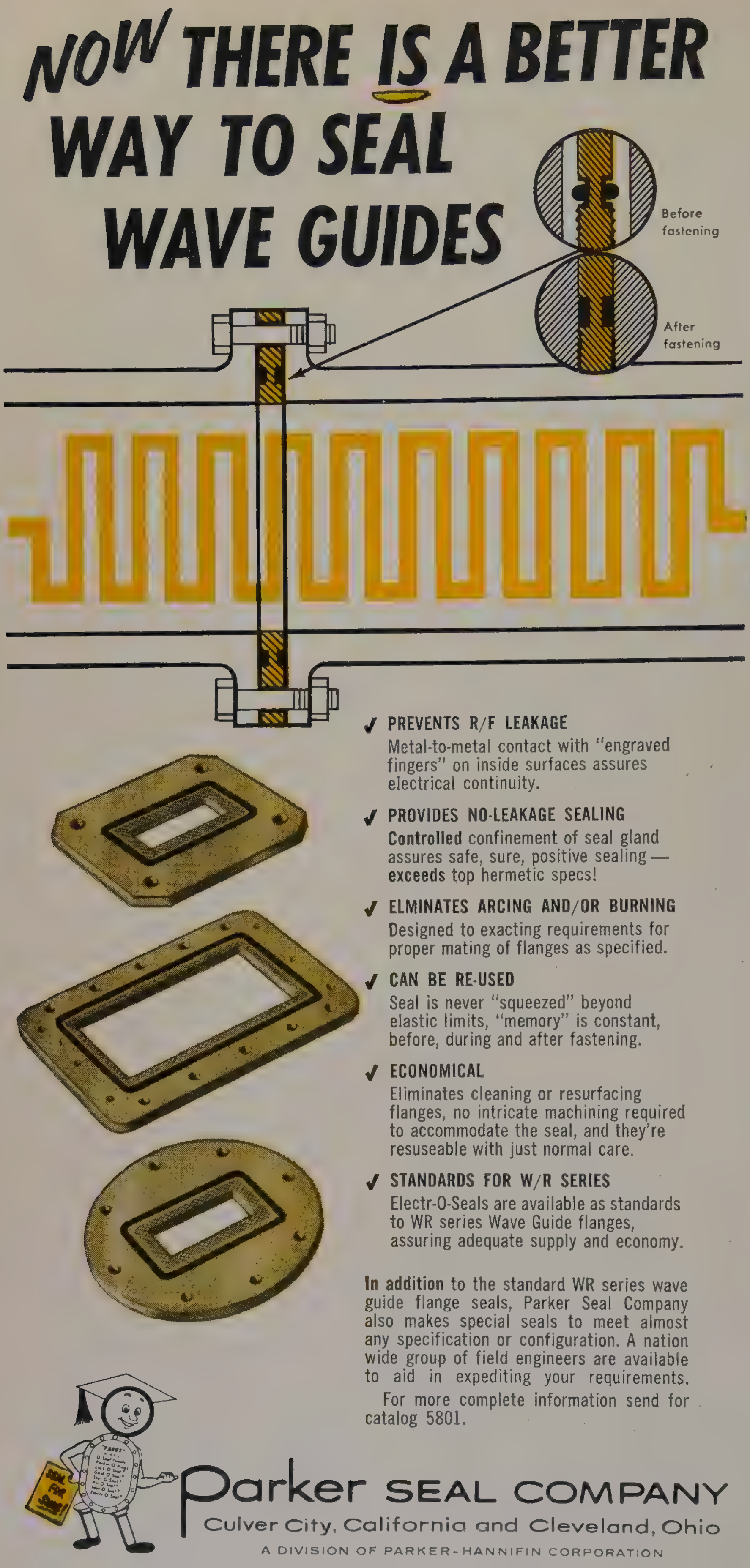

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Circle Reader Service Card 10

(*Continued from page 20*)

GALLAY NAMED DIRECTOR OF NEW MICROWAVE DIVISION

Mr. Harris Gallay of Fort Lee, N.J., has been named director of the newly formed Microwave Division of Electronic Research Associates, Cedar Grove, N.J.

The new division is engaged in the development and marketing of a complete line of commercial microwave communications equipment for single hop and relay applications.

Mr. Gallay has pioneered in microwave pulse communications at the IT&T Laboratories where he was responsible for the research and development of microwave ground based relay systems, as well as air-to-air time division and pulse multiplex communications systems, in which fields he holds a number of patents.

Mr. Gallay comes to ERA from the Curtiss Wright Electronics Division where he was engaged in the development of light-weight, high resolution, airborne Ka band radar systems.

—*mwj*—

ZAISS NAMED TO GE POST

Herman F. Zaiss, Jr. has been named Manager — Engineering Support for the Traveling-wave Tube Product Section of General Electric's Power Tube Department, Schenectady, N. Y., S. E. Webber, Manager — Engineering, has announced.

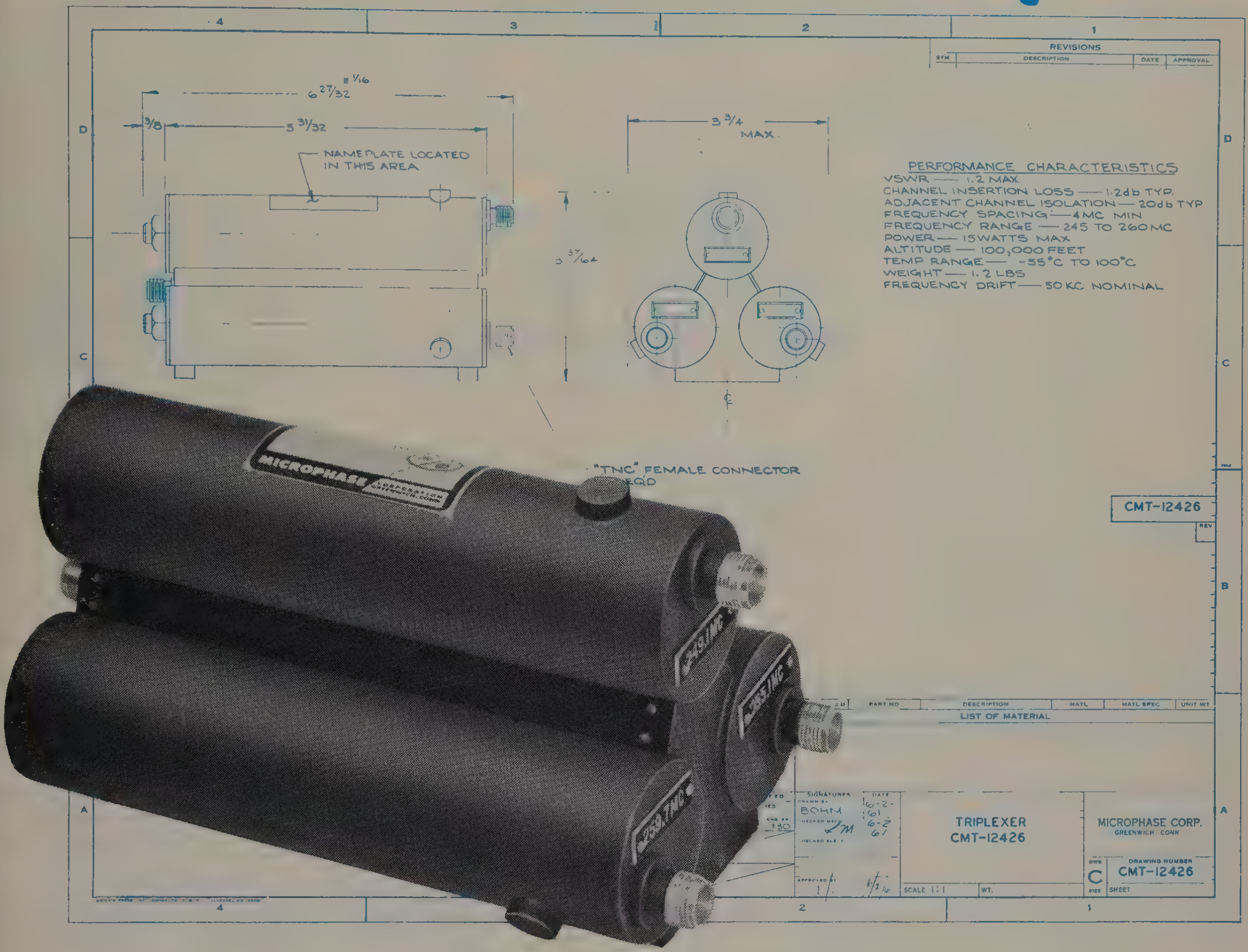
Mr. Zaiss, formerly manager of the klystron manufacturing unit at GE's Power Tube Department, will be responsible for all technical support services to the various engineering sub-sections at Palo Alto. These services include parts fabrication, assembly, processing and testing microwave tubes, applied research in physical and chemical technology, fabrication of special models, and technical drafting.

Mr. Zaiss, a native of Schenectady, was graduated from Rensselaer Polytechnic Institute with a bachelors degree in mechanical engineering in 1951. He joined the General Electric Company the following year on the engineering program and held varied assignments with several General Electric departments there. He transferred to the Power Tube Department in 1957 as a process engineer.

—*mwj*—

(*Continued on page 26*)

Antenna Couplers


6 27/32 ± 1/16
3/8
5 31/32
NAMEPLATE LOCATED IN THIS AREA
3 3/4 MAX
3 37/64
PERFORMANCE CHARACTERISTICS
VSWR — 1.2 MAX
CHANNEL INSERTION LOSS — 1.2db TYP.
ADJACENT CHANNEL ISOLATION — 20db TYP
FREQUENCY SPACING — 4MC MIN
FREQUENCY RANGE — 245 TO 260MC
POWER — 15WATTS MAX
ALTITUDE — 100,000 FEET
TEMP RANGE — -55°C TO 100°C
WEIGHT — 1.2 LBS
FREQUENCY DRIFT — 50KC NOMINAL
"TNC" FEMALE CONNECTOR
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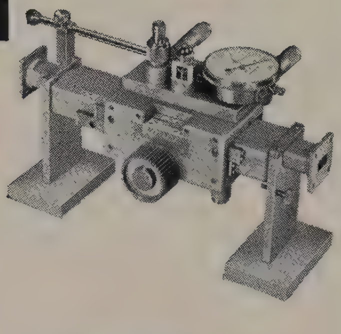
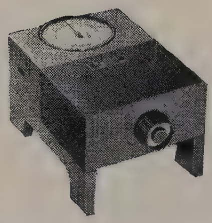
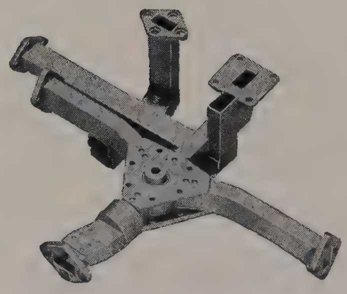
WAVEGUIDE SWITCHES





and **components**

MIXERS
FILTERS
ANTENNAS
DIRECTIONAL COUPLERS
WAVEGUIDE TEES
DETECTOR MOUNTS
DELAY LINES
HYBRIDS
POWER DIVIDERS
COMPLEX BENDS
MODULATORS
PRESELECTORS



Consult Waveline in order to achieve maximum compliance with your complex waveguide requirements. Standard instruments and special components are available.

WAVELINE INC.
CALDWELL, NEW JERSEY
Phone: CApital 6-9100 TWX Caldwell, N. J. 703

Circle Reader Service Card 12

Industry News

(*Continued from page 24*)

CHANGES IN BUSINESS TAX LAWS PROPOSED AT EIA CONVENTION

The Electronic Industries Association Board of Directors concluded EIA's 37th Annual Convention in Chicago recently by electing L. Berkley Davis, vice president of the General Electric Co., as EIA president for a second term, and naming other 1961-62 officers.

The board also gave its approval, in principle, to a proposal for legislative modernization of U. S. government regulations affecting international trade and a program for business tax reforms prepared by the association's Tax Committee.

Other highlights of the convention were: Presentation of the 1961 EIA Medal of Honor to Dr. Jerome B. Wiesner, special assistant to President Kennedy for science and technology, at the Annual Award Dinner; Authorization for publication of an electronics career booklet for high school students by EIA with the assistance of the Institute of Radio Engineers; Approval by the Consumer Products Division of publication of an informational booklet on FM stereo broadcasting for dealers, distributors, service shops, and FM broadcasters; A seminar on "Programmed Learning and the Electronics Industry" under sponsorship of the Industrial Electronics Division; and President Davis' annual report to the membership.

Eight new members were approved for EIA membership by the Board of Directors, bringing the total to 356. They are: Burnham and Co., New York, N.Y.; Diodes, Inc., Canoga Park, Cal.; Electra Manufacturing Co., Kansas City, Mo.; Electronic Industries, Inc., South Norwalk, Conn.; Kearfott Semiconductor Corp., West Newton, Mass.; MicroSemiconductor Corp., Culver City, Cal.; Semicon, Inc., Bedford, Mass., and Quantatron, Inc., Santa Monica, Cal.

— *mwj* —

BUDD-STANLEY TO OPEN NEW PLANT

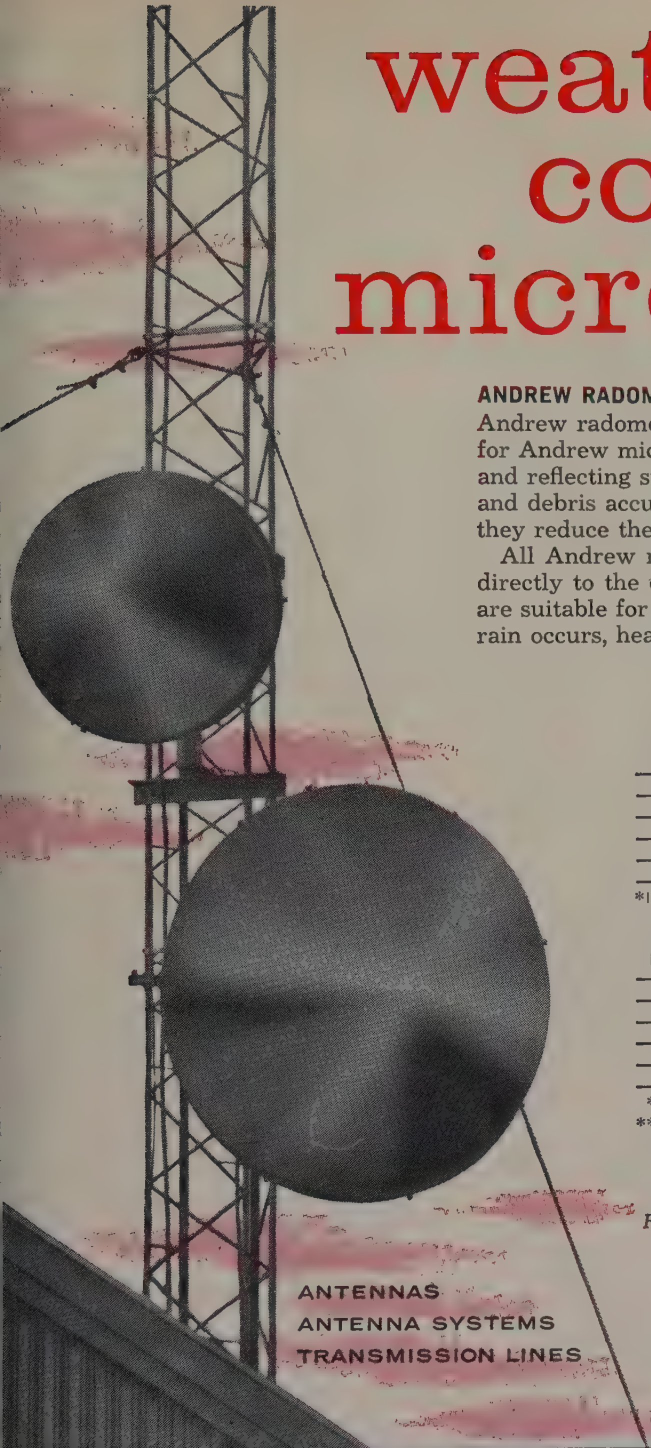
The Budd-Stanley Co., producers of microwave test instruments and components, has moved manufacturing facilities from Long Island City, N. Y. to a newly completed plant in Syosset, Long Island, it was announced by Stanley Gartman, chairman of the board.

The one-story structure is located in Syosset's Industrial Park section adjacent to the Long Island Railroad. Its 40,00 square foot capacity will enable the company to triple present production.

— *mwj* —

(*Continued on page 28*)

weather conditioned microwave



ANDREW RADOME EQUIPPED ANTENNAS DEFY ICE...SNOW...WIND

Andrew radomes provide excellent 2-way year-round protection for Andrew microwave antenna systems. First, they protect feed and reflecting surface against the attenuating effects of snow, ice and debris accumulation. Secondly, for tower mounted antennas they reduce the effects of wind thrust by 35%.

All Andrew radomes are lightweight and easy to install—clip directly to the dish rim of existing antennas. Unheated radomes are suitable for all but exceptional cases. In areas where freezing rain occurs, heated radomes can be provided.

SPECIFICATIONS

STANDARD RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc	Thrust at* 30 psf (Flats), lbs.
10	R10	0.4	0.02	1,990
8	R8	0.4	0.02	1,270
6	R6	0.4	0.02	714
4	R4	0.4	0.02	320
2	R2	0.4	0.02	75

*Including antenna

HEATED RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc.	Thrust at* 30 psf. (Flats), lbs.	Power** Reqmts.
10	HR10	0.7	0.02	1,990	3,400 watts
8	HR8	0.7	0.02	1,270	2,400 watts
6	HR6	0.7	0.02	714	1,200 watts
4	HR4	0.7	0.02	320	550 watts
2	HR2	0.7	0.02	75	150 watts

*Including antenna

**Power requirements for HR10 and HR8 are 3 wire single phase 60 cycle 220 volts.

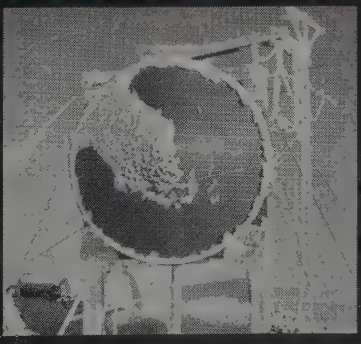
Power requirements for HR6, HR4 and HR2 are single phase 60 cycle 115 v.

For further details on ANDREW Microwave Antennas, Radomes, Wave Guides write for new Andrew Catalog M.

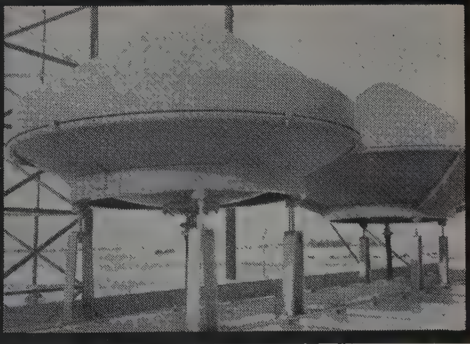
ANTENNAS
ANTENNA SYSTEMS
TRANSMISSION LINES

Andrew
CORPORATION
P. O. Box 807, Chicago 42, Illinois
Boston • New York • Washington • Los Angeles • Toronto

‘We have paid particular attention to antennas luring high wind conditions of gusts up to 40-60 n.p.h. It is very obvious that these radomes quite materially reduce the wind loading on the oarabolas—due to their shape factor.” *Washington State Patrol, Kennewick, Washington*



“We have had up to four inches of ice on the radome with practically no reduction of antenna effectiveness.” *KLIX-AM-TV, The KLIX Corporation, Twin Falls, Idaho*



“Our field forces report that the radomes produce a signal loss of less than 1 db per antenna. Several radomes were removed and antennas inspected following a heavy snow storm and no snow or ice was found in the antennas.” *Natural Gas Pipeline Company of America*

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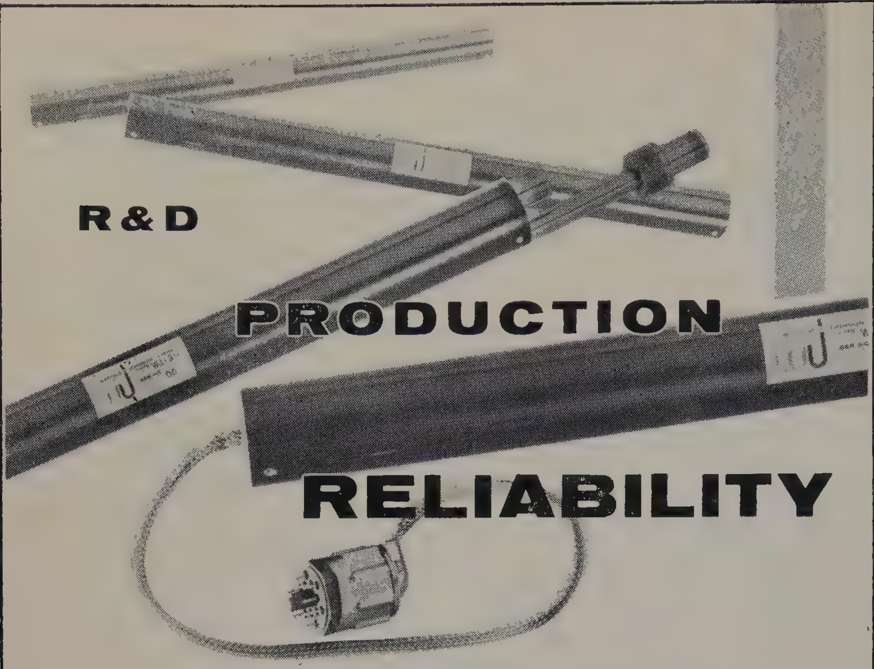

R&D

PRODUCTION

RELIABILITY

Employment of professional skills, advanced techniques, and modern facilities has led to a production capacity aimed at the utmost reliability in a wide range of frequencies and power levels in microwave vacuum tubes.

Ultra low-noise traveling-wave amplifiers in production quantities are available in the following specfications:

Model Number	Nominal Terminal Noise Figure (db)	Frequency (kMc)
WJ-211	4.3	2.0-4.0
WJ-211-1	3.5	2.1-2.4
WJ-211-2	3.4	2.3-2.7
WJ-211-3	3.9	2.5-3.5
WJ-212	4.0	1.0-2.0
WJ-212-1	3.6	1.1-1.6

Information in more detail available from representatives in your area, or from

APPLICATIONS ENGINEERING
WATKINS-JOHNSON COMPANY

3333 HILLVIEW AVENUE
STANFORD INDUSTRIAL PARK
PALO ALTO, CALIFORNIA

Circle Reader Service Card 14

Industry News

(*Continued from page 26*)

RESEARCH FIRM MOVES TO MARYLAND

Electromagnetic Research Corp. announces that it has moved from offices in Washington, D.C. to its new laboratories in suburban College Park, Md. This location is within a mile of the University of Maryland campus and is adjacent to the College Park airport, where much of the early test work on radio aids to air navigation was carried out.

The new quarters combine offices and laboratories in a completely air-conditioned, one-story building. Floor space is over 8300 square feet, divided into 14 offices and two large laboratory areas.

One of the laboratory areas is occupied by an array of 35 electronic test benches and a model shop. The other is used for extensive test setups. The facilities also include an LGP-30 digital computer.

—*mwj*—

GE APPOINTS MILITARY ELECTRONICS CHIEF

Robert J. Brown has been appointed head of the General Electric Company's multi-million dollar ground and shipboard military electronics business, in Syracuse, N.Y., according to Dr. George L. Haller, G.E. vice president and general manager of the Defense Electronics Division.

The new general manager of the Heavy Military Electronics Department has been closely associated with military electronics for more than 18 years. After graduating the Southwestern Louisiana Institute in 1942 with a BS degree in electrical engineering, Mr. Brown joined General Electric as a test engineer assigned to developing microwave circuitry for laboratory equipment.

His latest position was manager of marketing for the Heavy Military Electronics Department.

Mr. Brown is a member of the board of directors of the newly organized Apparaten Industrie Defense Electronics Company (AIDE), General Electric subsidiary in the Hague, Netherlands and a member of the board of directors of the Syracuse chapter of the Armed Forces Communications and Electronics Association.

—*mwj*—

(*Continued on page 30*)

60 MILLIWATTS OF *Versatility*

with the **NEW**

SPERRY *Microline*®

SWEPT OSCILLATOR

MICROWAVE SWEPT OSCILLATOR SPECIFICATIONS

Microline Number	Output frequency GC	Minimum Power mw	Sweep Rate seconds
64S1	2.0 - 4.0	60	.01 to 100
64C1	4.0 - 8.0	20	.01 to 100
64X1	8.2 - 12.4	20	.01 to 100

Modulation: Internal grid modulation, 1000 cps. or provision for external modulation.

Levelling: Output level controlled from front panel. Provision for external level control for programming output level.

Frequency Scale: Slide rule dial accurate to 1 percent.

Sweep: Linear, with time to 1 percent.

Size: 12¼″ x 19¼″ x 17¾″.

Power: 105 - 125 / 210 - 230 volts; 50 - 60 cps.

Features which make this oscillator superior for any microwave measurement:

Sweep: End points independently adjustable over entire frequency range. Sweep may be from low to high, or high to low frequency. Sweep rates continuously variable in four ranges from .01 to 100 seconds. There is provision for external sweep, dc coupled, to permit frequency programming. Manual recurrent or triggered sweep and front panel indication, with meter and lamp, when sweeping.

Markers: Five separate markers at the start and stop frequencies and any three intermediate points. Markers can be set directly from front panel meter, or readily with an external wavemeter using the unique spot frequency selection feature.

Spot Frequency Selection: Five spot frequencies are available, which are independently selected by the start, stop and three marker settings. The Microline oscillator is a five-frequency, preset signal generator as well as a swept oscillator.

The new Sperry Microline swept oscillator is offered in three output frequency ranges.

DIVISION OF SPERRY RAND CORPORATION

SPERRY

MICROWAVE ELECTRONICS COMPANY,
CLEARWATER, FLORIDA

Microline Instruments • *Radar Test Sets* • *Systems Instrumentation*
Solid State Devices and Materials • *Microwave Components and Antennas*

SEE THIS NEW OSCILLATOR IN OPERATION AT WESCON, BOOTHS NOS. 3111-3121

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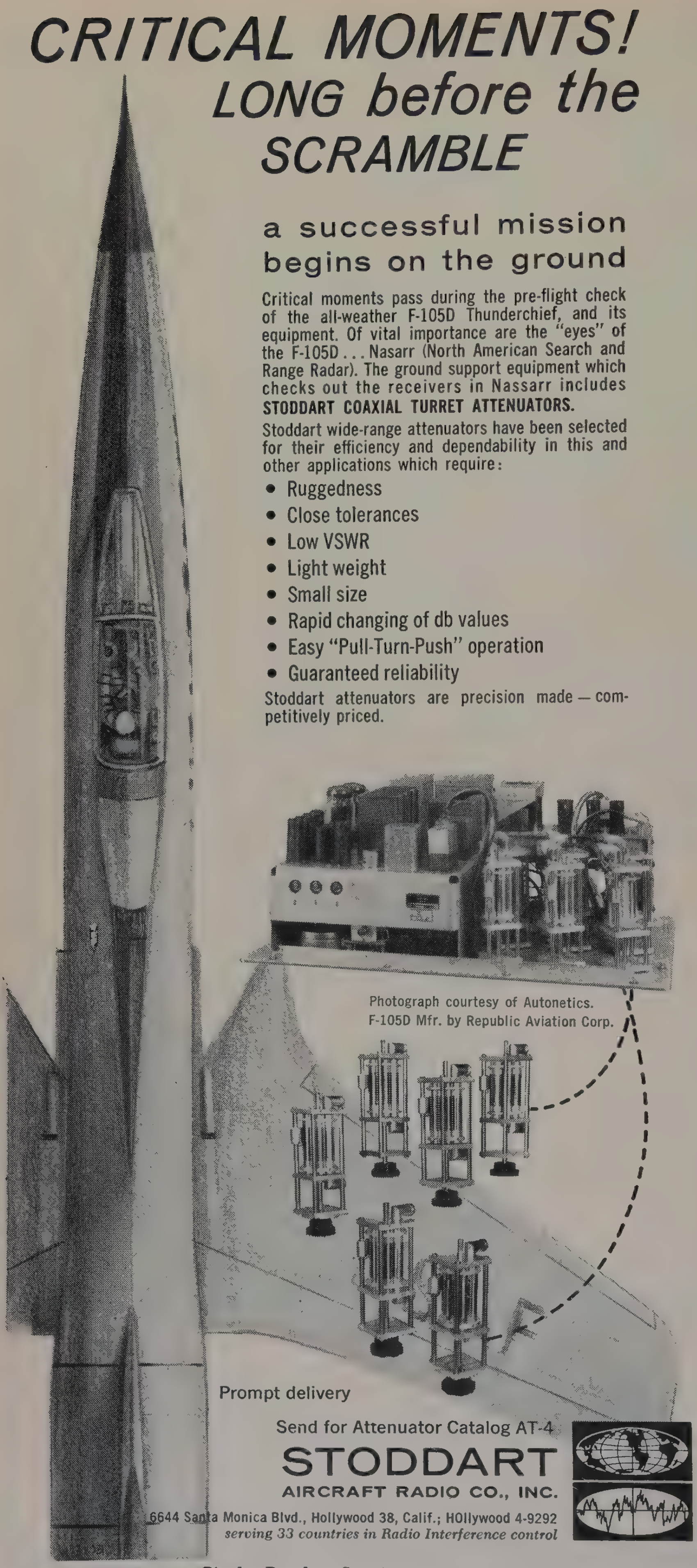
CRITICAL MOMENTS! LONG before the SCRAMBLE

a successful mission begins on the ground

Critical moments pass during the pre-flight check of the all-weather F-105D Thunderchief, and its equipment. Of vital importance are the "eyes" of the F-105D . . . Nasarr (North American Search and Range Radar). The ground support equipment which checks out the receivers in Nassarr includes **STODDART COAXIAL TURRET ATTENUATORS.**

Stoddart wide-range attenuators have been selected for their efficiency and dependability in this and other applications which require:

- Ruggedness
- Close tolerances
- Low VSWR
- Light weight
- Small size
- Rapid changing of db values
- Easy "Pull-Turn-Push" operation
- Guaranteed reliability

Stoddart attenuators are precision made — competitively priced.

Photograph courtesy of Autonetics.
F-105D Mfr. by Republic Aviation Corp.

Prompt delivery

Send for Attenuator Catalog AT-4

STODDART
AIRCRAFT RADIO CO., INC.
6644 Santa Monica Blvd., Hollywood 38, Calif.; HOllywood 4-9292
serving 33 countries in Radio Interference control

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(Continued from page 28)

SYMPOSIUM ON ELECTROMAGNETIC THEORY AND ANTENNAS SCHEDULED

A "Symposium on Electromagnetic Theory and Antennas" will be held at the Technical University of Denmark, Copenhagen from June 25th to June 30th, 1962. This will be a continuation of three previous symposia, namely the "Symposium on Microwave Optics" held at McGill University, Montreal, Canada in 1953, the "Symposium on Electromagnetic Wave Theory" held at the University of Michigan, Ann Arbor, Michigan, in 1955, and the "Symposium on Electromagnetic Theory" held at Toronto University, Toronto, Canada in 1959. The symposium will be open to any interested person from any country.

The symposium will be devoted to subjects of current importance in electromagnetic theory and its applications. Papers dealing with the following subjects are encouraged: electromagnetic fields in anisotropic media, such as plasmas and ferrites; diffraction theory; scattering in random media; quasi-static electromagnetic problems; theory of broad-band antennas; and antenna pattern synthesis.

Most of the technical sessions will be opened with an invited, introductory paper and will then be followed by a series of shorter papers with interspaced discussions. It is expected that the USSR delegation will undertake the complete arrangement of two of the technical sessions.

Further information about the symposium will be sent upon request when it is available from:

H. Lottrup Knudsen, Secretary
Symposium on Electromagnetic
Theory and Antennas
Oster Voldgade 10 G
Copenhagen K
Denmark

—*mwj*—

AEL GRANTED CONTRACTS TOTALLING $500,000

AEL, Inc., Philadelphia, Pa., has announced the procurement of new contracts totalling $500,000.00.

Included is a contract of $325,000.00 for development and production of antennas. This is in addition to a currently existing $450,000.00 contract. The work will be handled by the company's Component Division, which specializes in the design and development of antenna systems and microwave components.

Development and production will be carried out at AEL's soon-to-be-completed research and manufacturing center located on the company's 55 acre tract at Colmar, Pa.

—*mwj*—

(Continued on page 34)

ERRITE SOLATORS

y D-B

for xceptionally igh erformance... a full range f sizes... 0-day deliveries

DE MORNAY BONARDI

E=mc²

®

D-B supplies ferrite isolators covering a range from 2.6 to 18.0 kmc. Units will soon be available to 140 kmc. All units in the line have the following high-performance features:

High isolation—a minimum of 30 db at X Band, and 24 db at Ku Band.

Low insertion loss—a maximum of 1.0 db in *all* sizes.

DeMornay-Bonardi isolators are resonance absorption type units, employing a low-loss ferrite developed especially for this application.

Low VSWR—a maximum of 1.15 in either direction.

Short insertion lengths—only 5⅞″ in X Band size.

Complete data in Bulletin DB-480.

Other ferrite units manufactured by DeMornay-Bonardi include: Frequency Converters, Circulators, and Harmonic Rectifiers using unique D-B ferrite compounds.

D-B
- a reliable supplier

As the oldest manufacturer of microwave equipment, we have the talents to design reliable instruments . . . the skills to manufacture them, and the complete equipment for checking and calibration. You'll find deliveries prompt now at D-B, and, as always, every instrument backed by a firm replacement guarantee.

DE MORNAY-BONARDI 780 South Arroyo Parkway, Pasadena, California

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And delivered before they were ready for it.

JVM has engineered and constructed over 350 *different types* of triode cavities — by far the most complete selection available. Usually, one of these types, standard or slightly modified, will meet your requirements exactly. Fabrication and assembly can be completed in a few days, permitting the unusually short 30 day delivery schedule. Totally new designs take a little longer. And the high degree of standardization at JVM results in triode cavities of superior reliability at lower prices. Plan now to discuss your triode cavity needs with JVM. Write for the new technical brochure, complete with performance data, on JVM TRIODE CAVITIES.

JVM DIVISION OF — Fidelitone Microwave Inc.
Chicago 26, Illinois

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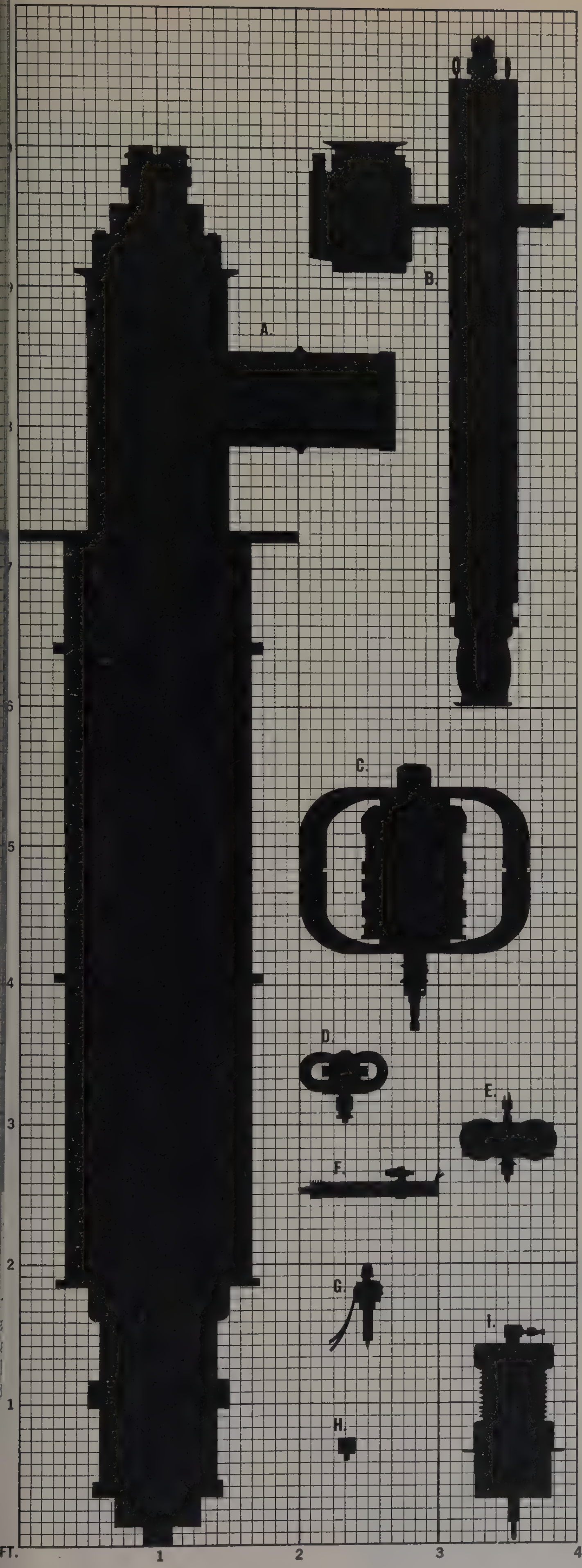


ONE METER TO FOUR MILLIMETERS

New Litton Electron Tubes for Advanced Applications

A. L-3403 KLYSTRON TUBE: One of our super power line, a long pulse, power amplifier klystron for the Ballistic Missile Early Warning System, delivering 1.25 megawatts peak power output.

B. L-3270 BROADBAND KLYSTRON: A 2 megawatt L-band klystron offering long life, high peak power, 8 percent bandwidth. Other broadband klystrons, using the exclusive Litton Skirtron techniques, are available with higher power in the L through S-band region with .002-.004 duty cycles.

C. L-3455 HIGH POWER MAGNETRON: A new magnetron delivering a minimum of 2 megawatts peak power at 406-450 mc. with a .002 duty cycle.

D. L-3458 HIGH TEMPERATURE PULSE MAGNETRON: Provides long life operation at ambient temperatures in excess of 662°F. Many hours of 900°F. operation have been achieved in X-band tests.

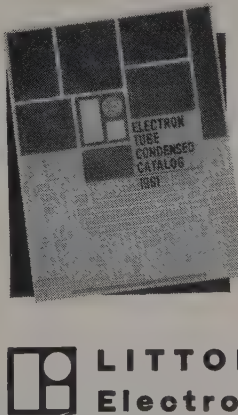
E. L-3629 FLOATING DRIFT TUBE KLYSTRON: High power, water-cooled klystron oscillator fixed tuned at 33,000-37,000 mc. Power output: 15 watts CW minimum. Other tubes available for immediate delivery from 12-4 mm. wavelength.

F. L-3472 TWT: PPM focused traveling wave tube offers higher CW power — 10 watts minimum — and wider bandwidth in a compact 3-lb. size. Operates in the range of 7,000-11,000 mc. One of a line of TWT's including a 1000-watt X-band pulse tube.

G. MICROTRON: The L-3189, one-kilowatt CW magnetron, is accompanied in package form by an electromagnet and filter assembly, high voltage and filament and isolation transformers. Only 6-second warm-up. Two year warranty for domestic microwave cooking.

H. L-3430 CUBE MINIATURE MAGNETRON: A one-kilowatt miniature magnetron, fixed tuned at 9300 ± 30 mc, weighing less than 9 ounces and no bigger than a normal X-band waveguide flange. Developments at other power levels and frequencies are planned.

I. L-3408 SWITCH TUBE: Provides switching at relatively low control voltage levels with an efficiency of 95 percent. Features high voltage holdoff, high current handling. Collector ratings: 150 Kv; 20 Amps; 10 KW dissipation.



For information on our tube line, exclusive of classified types, send for the 1961 Electron Tube Condensed Catalog. Write to: Marketing Dept., Electron Tube Division, 960 Industrial Road, San Carlos, California

LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

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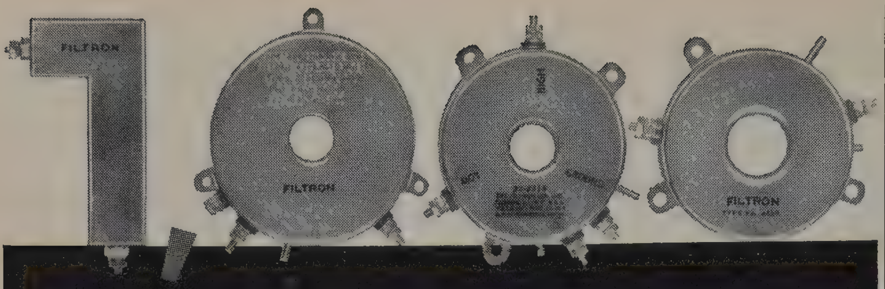

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SEVEN THOUSAND

FILTRON®

RF FILTER TYPES

FILTRON RF filters have suppressed unwanted interference signals virtually everywhere...in radar, electronic and electrical equipment...manned aircraft...missiles...satellites...weapons systems...launching platforms...and shielded laboratories too! These applications have required suppression throughout the entire electro-magnetic spectrum — from 30 cycles to over 50,000 megacycles—both broadband and narrow band. In all, more than 7,000 different types of Filtron RF interference suppression filters have been designed and manufactured under Filtron's exclusive patented circuit design. Millions are in use today.

If electrical disturbance is interfering with the satisfactory operation of your device, on land, sea or in the skies...FILTRON has a solution to meet all military specifications.

FILTRON® COMPANY, INC.

FLUSHING 55, N. Y. • CULVER CITY & PALO ALTO, CALIF. • DAYTON, OHIO

RF INTERFERENCE FILTERS • RADAR PULSE PACKAGES • PULSE FORMING NETWORKS
SPECIALTY CAPACITORS • DELAY LINES

RF INTERFERENCE TESTING • SYSTEMS ENGINEERING

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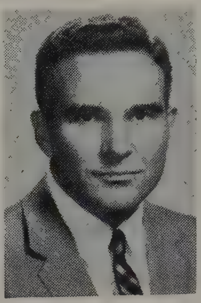
Industry News

(Continued from page 30)

STRAND LABS CHOOSES NEW PRESIDENT



Robert G. Crooks has been elected president of Strand Labs, Inc., Newton, Mass., manufacturers of microwave signal generators and paramagnetic research equipment. Mr. Crooks replaces Dr. Henry J. Riblet, who has assumed the post of chairman of the Board of Directors.

Mr. Crooks previously served as counsel to the McMillan Industrial Corp., and McMillan Laboratory, Inc.

The election of Mr. Crooks is part of an expansion program to increase the participation of Strand Labs., Inc., in the growing microwave instrument field. The firm's expansion program includes accelerated research and development activity in both existing product areas and related new fields such as magnetometers and complex-reflection-coefficient measuring instruments.

Mr. Crooks holds a masters degree in electrical engineering from M.I.T. and a law degree from George Washington University.

—*mwj*—

NAVY AWARDS SPERRY MISSILE GUIDANCE RADAR CONTRACT

A $33,400,000 contract for continued production of highly accurate automatic missile guidance radar systems used in the Navy's TERRIER missile program was awarded by the Bureau of Naval Weapons to the Sperry Gyroscope Co., Great Neck, N.Y., it has been announced.

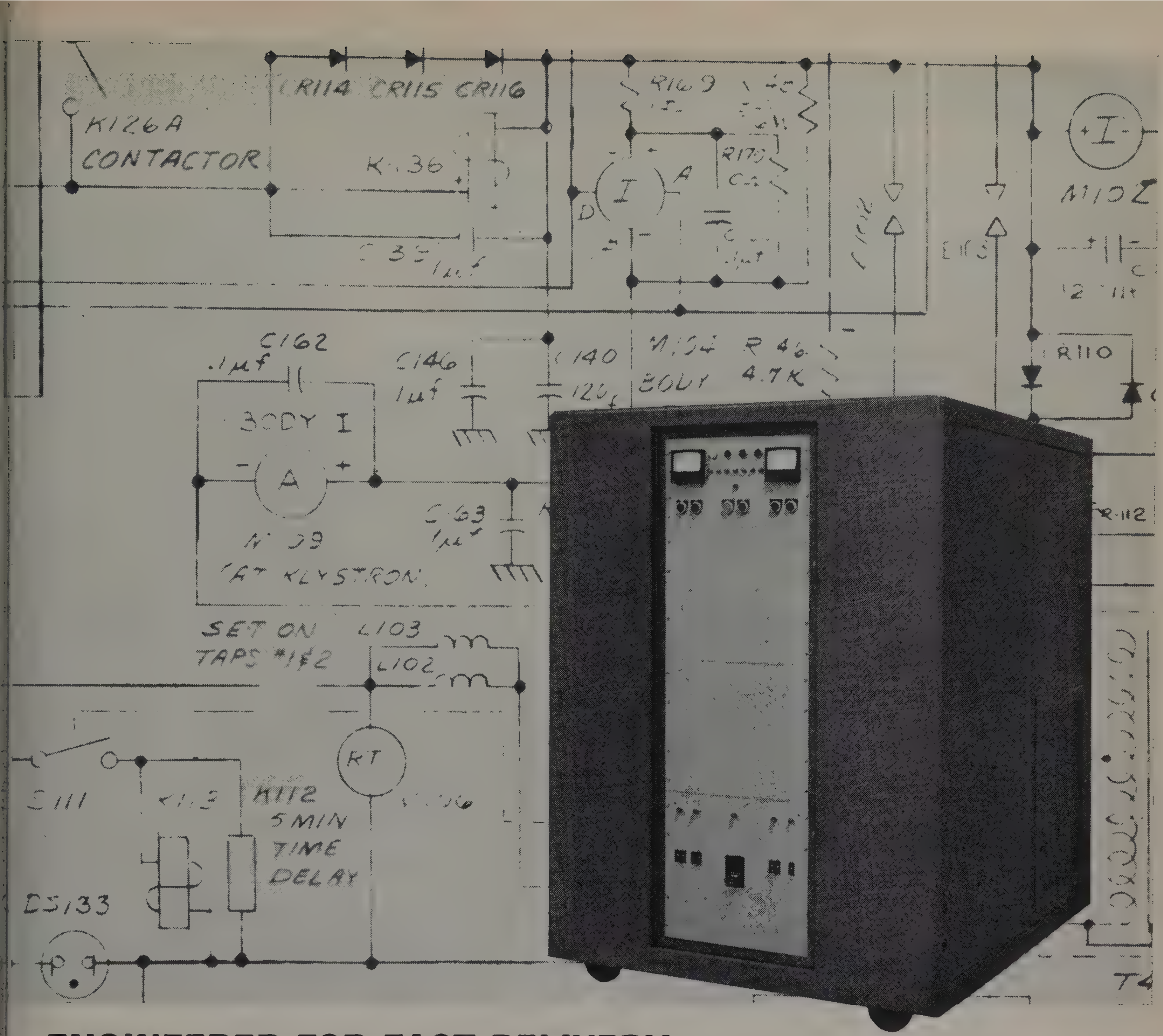
The advanced super radars, designated AN/SPG-55, accomplish the two-fold task of tracking the target accurately and precisely guiding the deadly, surface-to-air TERRIER missile's interception.

The completely automatic system allows the radar operator to act solely as an observer. Sperry equipment also controls launching and computation functions.

Developed and produced since 1957 for the Navy by Sperry, the SPG-55 has been installed aboard the Navy's first nuclear-powered cruiser, the USS LONG BEACH. The system also is employed on several guided missile destroyers and frigates, and other surface craft.

—*mwj*—

(Continued on page 49)



ENGINEERED FOR FAST DELIVERY ...STANDARD POWER SUPPLIES FROM 10 TO 600 KVA

unctional design is an important advantage of power pplies offered by Radiation at Stanford (formerly Levin-al). They are carefully engineered to permit rapid pro-uction and prompt delivery of units with the exact aracteristics you require.

Radiation at Stanford power supplies offer maximum exibility—whatever your application—and are distin-uished by these standard features:

Choice of output—10 to 600 kva; 10 to 55 kv

Output continuously variable from 0 to full voltage

Reversible output polarity

Low ripple—down to 0.05%

Protection against equipment damage and personnel hazard by complete set of interlocks with fail-safe indicators

- Protective circuitry for all meters against load short-circuit damage
- Circuit breakers throughout
- Magnetic component protection against over-voltage by spark gaps and auto-valves
- Simplified control—through use of "System ON-OFF," "High Voltage ON-OFF," and "High Voltage RAISE-LOWER" controls

Special brochure contains complete technical information on our standard line of "custom" supplies. For your copy, write or call Radiation at Stanford, 3180 Hanover Street, Palo Alto, California.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

RADIATION
at Stanford

Circle Reader Service Card 21

A new 30′ mesh surface antenna from Antenna Systems

This newly designed parabola (Model 101) has a lot to recommend it. For instance:

Versatility — the 101 is suitable for radio astronomy, tropospheric scatter, tracking radar, and experimental test stations. Its f/d ratio of 0.417 adapts to a wide variety of feed systems.

Ruggedness — it can operate under 150 mph winds and 4″ of ice.

Easy assembly — its expanded, reinforced aluminum mesh panels are fully interchangeable. It can be either top – or side-mounted on a tower with azimuth and elevation adjustments, or on el-az or equatorial pedestals, self-contained trailer tower mounts, or other types.

Accuracy — overall static surface tolerance is better than ±0.25. And, if higher accuracy is required, ASI can equip the 101 with solid surface panels which will permit its use at frequencies above 10,000 megacycles.

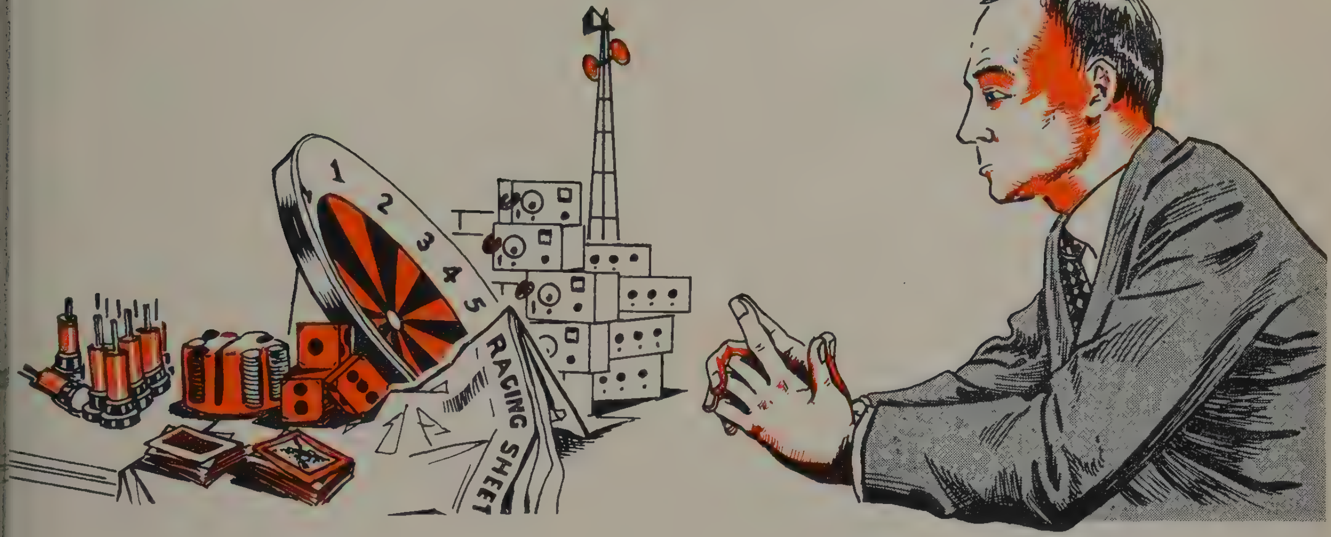
Unfortunately, we can't mail you the Model 101 for a free trial — but we can send you complete information. Matter of fact, we can help you with any antenna problems you may have. Just write:

ASI

ANTENNA SYSTEMS INC
HINGHAM, MASSACHUSETT

FOR ANSWERS TO PROBLEMS IN THE DESIGN, FABRICATIO
AND INSTALLATION OF ANTENNA SYSTEMS, ASK AS

the electronic gambler



By PETER D. STRUM

Compulsive gambling is generally regarded as socially nacceptable. The connotation is that the individual in-olved is a weakling, unable to control his own actions. ndoubtedly this picture is often true. But I wonder hether the deep-seated urge, bordering on compulsion, stake "everything" on one's ability to do something new nd different is not closely related. Yet, the successful mbler in a new business venture is lauded for his sucss. Perhaps it is only the symbol of failure that is unceptable.

As Gershon Wheeler set forth in these columns last ar, there are many possible "last straws" that cause sci-ntifically trained people to "kick over the traces" and art a new microwave business. Underlying every in-ance there is always that urge to gamble on one's own bility to create something worthwhile and hence success-l.

The magnitude of the gambling element in new enterprises has a wide range of possibilities as determined by what the entrepreneur puts on the line in return for his potential rewards. The ante, which may be lost, may range from a small part of one's reputation to complete economic enslavement. The rewards may range from small partial ownership to complete ownership and mastery of an economically successful business.

Once the initial step of starting a new business has been taken, whatever the ante and potential reward, there is a wide range of available odds as determined by management policies. On one extreme is the low-odds policy of accepting only cost-plus-fixed-fee contracts. At the other extreme is the long-shot policy of going all-out to do advanced development work at a fixed price. Probably neither extreme alone gives the best odds.

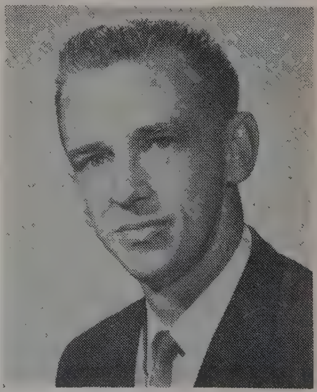
The conservative policy of CPFF alone is economically

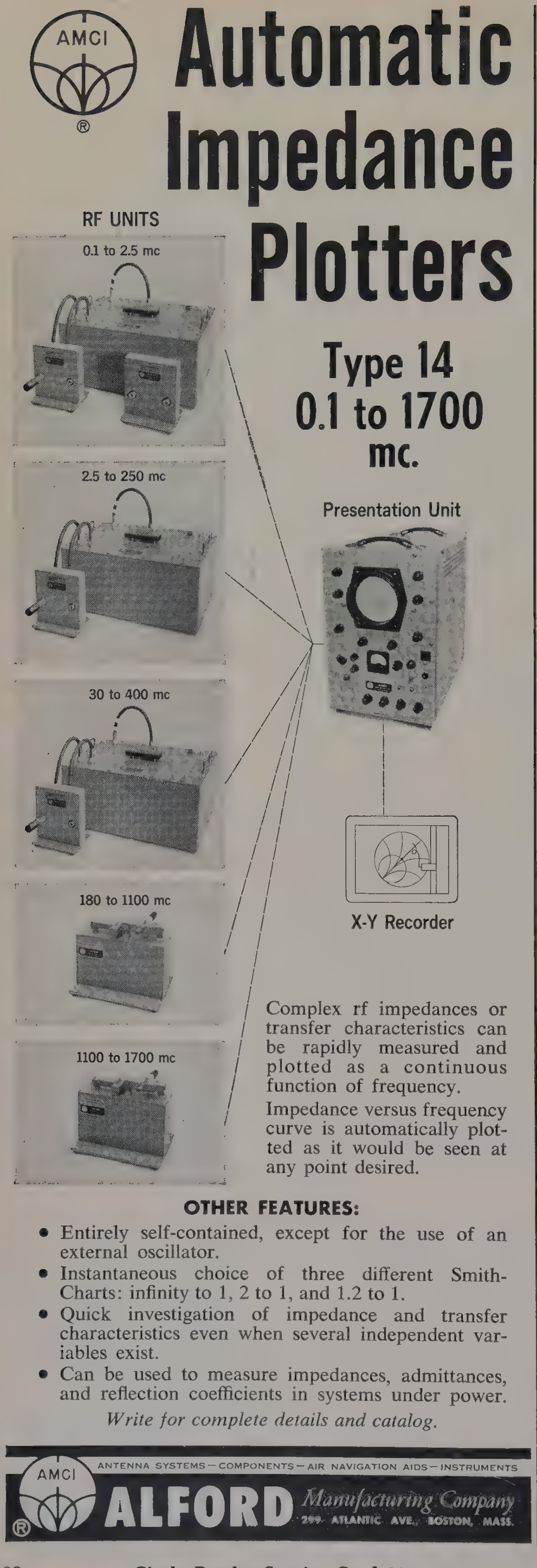
(*Continued on page 38*)

ETER D. STRUM is Vice President of Applied Technology, Inc. In its two years f operation ATI's staff has grown from four to 25 and its annual sales rate has sen to about three-quarters of a million dollars, mostly in fixed-price development ork.

Mr. Strum has for many years been active in the development of low-noise icrowave receiving systems and instrumentation for noise measurement at Air-orne Instruments Laboratory, Ewen Knight Corp., and Granger Associates.

He has been active locally and nationally in the affairs of the IRE Professional roup on Microwave Theory and Techniques, having served both as Secretary and s Member of its Administrative Committee. In 1958 he was corecipient of the nnual Award of the National Electronics Conference. He is a member of Sigma i, Tau Beta Pi, and Eta Kappa Nu.





AMCI ®

Automatic Impedance Plotters

RF UNITS

0.1 to 2.5 mc

2.5 to 250 mc

30 to 400 mc

180 to 1100 mc

1100 to 1700 mc

Type 14
0.1 to 1700
mc.

Presentation Unit

X-Y Recorder

Complex rf impedances or transfer characteristics can be rapidly measured and plotted as a continuous function of frequency.

Impedance versus frequency curve is automatically plotted as it would be seen at any point desired.

OTHER FEATURES:

- Entirely self-contained, except for the use of an external oscillator.
- Instantaneous choice of three different Smith-Charts: infinity to 1, 2 to 1, and 1.2 to 1.
- Quick investigation of impedance and transfer characteristics even when several independent variables exist.
- Can be used to measure impedances, admittances, and reflection coefficients in systems under power.

Write for complete details and catalog.

ANTENNA SYSTEMS — COMPONENTS — AIR NAVIGATION AIDS — INSTRUMENTS

AMCI ® ALFORD *Manufacturing Company*
299 ATLANTIC AVE., BOSTON, MASS.

STRUM

(Continued from page 37)

"safe." Furthermore, with the assistance of sympathetic auditors, a company can quite legally support substantial growth through the benevolence of the Government. An attractive feature of this form of contracting is that cash flow can be accelerated by establishing short-term billing and assigning the contracts to a friendly banker at a small discount. In this way cash can be rotated many times a year. Hence, if after disallowances one realized a few percent per rotation, a tidy earning rate can be achieved. On the other hand, the CPFF contractor who continually relies on the "bail-out" for protection will eventually be discredited for incompetence. This less tangible risk should be considered carefully. Besides, unless a "change of scope" can be argued convincingly, the earning rate may drop to nil.

Another policy, about mid-way in the odds table, would be to have a number of known products to be sold at a fixed price with a substantial mark-up. The gamble here is with obsolescence and the sometimes cut-throat practices of a highly competitive field. But, if a fixed price can be maintained at an attractive level, the returns can be high.

As vice president of a small new company dealing principally in microwave system development I feel that most development work can be done at a fixed price. Many feel that such a gamble is an invitation to disaster. This need not be true if the management team has a firm grasp of the costs and contingencies of the business. This is a big IF, not to be treated lightly. It is the sort of thing that turns a technical entrepreneur from an engineer into a cash flow expert overnight.

The returns, however, may be several times those on comparable CPFF work without resulting in prohibitive prices. Seldom is the outcome of competitive bidding determined by a few percentage points, yet a small percentage increase in the price of a job, frequently well within the tolerance of the overall price estimate, can mean a factor of 2, 3, or 4 in the net returns. If then the rotation of cash can be arranged at the same rate as cited earlier, the basis for an urge to gamble is established. Time will tell in our own case whether our confidence in such an enterprise was foolish.

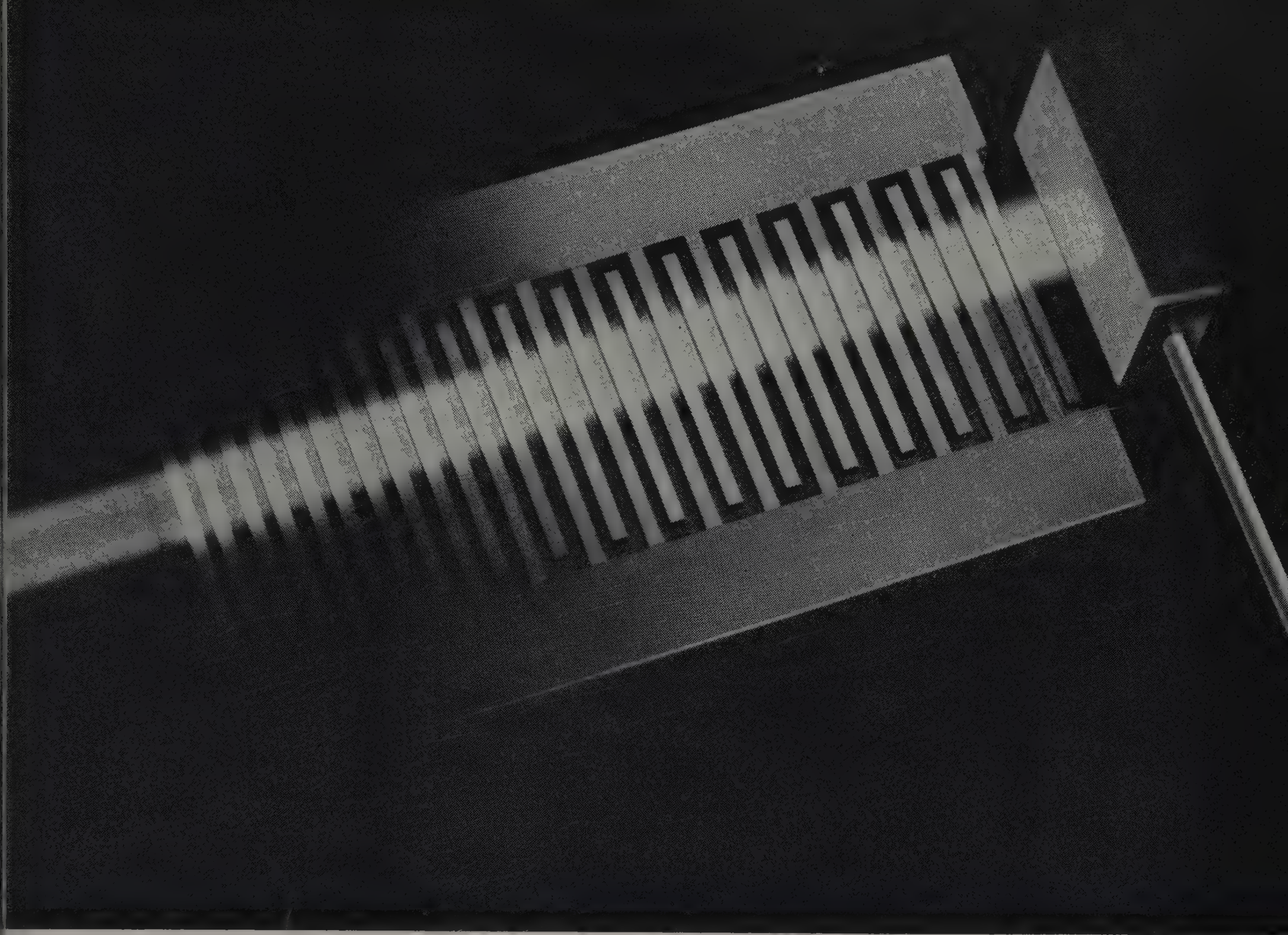
Regardless of that possible outcome, I believe that such a basis for operation in our industry is sound. It certainly encourages those involved to be more efficient than they might otherwise be. Tight schedules and cost controls become mandatory. And, as one might expect, occasional barrels of midnight oil must be burned. The challenge however, is stimulating and exciting.

In a talk recently before the San Francisco chapter of the Professional Group on Engineering Management of the IRE, Jack Melchor likened the technical entrepreneur to the pioneers who more than a century ago faced Indians and other hardships in seeking their fortunes in the West. Each in his own way risked being "scalped" in return for a chance at a big reward.

As an extension of this analogy the entrepreneur who does development for a fixed price may be likened to the incautious pioneer who chose his route near the Indian nation to cut down the time to his destination. Who knows whether the natives are friendly?

Circle Reader Service Card 23

ANOTHER ADVANCED MICROWAVE TUBE DEVELOPMENT
FROM RAYTHEON'S SPENCER LABORATORY



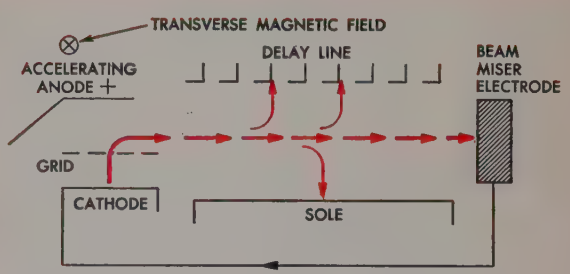
How new Raytheon "BEAM MISER" boosts efficiency in crossed field devices

Unique depressed collector greatly improves efficiency of "M" BWO's and crossed field amplifiers.

"Beam Miser" is Raytheon's newest advance in crossed field oscillator and amplifier design. With it are opened many new design possibilities for applications requiring voltage tunability or bandwidth plus high reliability and efficiency.

Incorporating the "Beam Miser" into existing crossed field tubes will yield improved performance and *will not require any mechanical or electrical changes in equipment.*

Write for further information on Raytheon developments in crossed field devices. Microwave & Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.



"BEAM MISER" consists of an additional electrode in the crossed field device which collects a portion of the spent beam at cathode potential and returns it to the cathode by means of an internal conductor.

RAYTHEON COMPANY

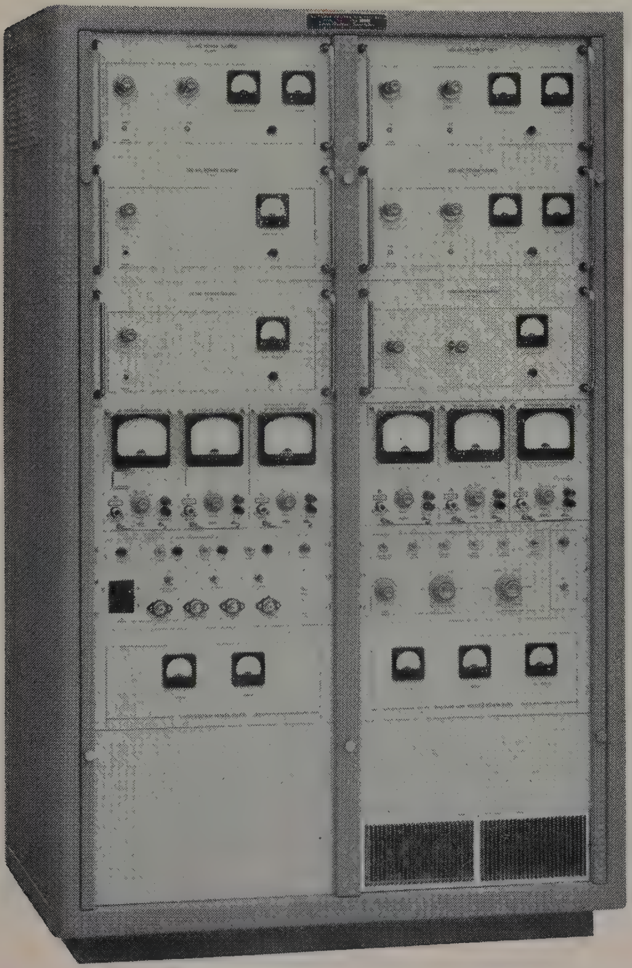
RAYTHEON

MICROWAVE & POWER TUBE DIVISION

Circle Reader Service Card 24

SIX POWER SOURCES

Unique accuracy and dependability



in a versatile new Sierra RF Calibration Test Set

Think of the many applications YOU have for a single system that gives you variable power to 125 watts at RF frequencies of 30, 100, 300, 400, 500 MC, to 60 watts at 1300 MC!

Besides being able to calibrate many forms of power-measuring devices to 1% accuracy (0.5% probable accuracy), you can use this test set as a convenient precision source of high-power RF for applications such as antenna and interference measurements.

Sierra Model 1223 includes six power sources, six power monitors, power and frequency selector unit, blower unit, control unit and two regulated power supplies—all housed in a 19-inch double rack.

The crystal-controlled power sources are highly stable, providing frequency accuracy within 0.01%. For calibrating calorimeters, bolometer and thermistor type power meters, and other devices for detecting RF power levels, just connect the device, select the frequency and power level, and compare the device reading against the known power of the test set. A factory-furnished potentiometer and voltage/power table provides additional calibration accuracy over the panel-mounted power meter.

The six unique power monitors, one for each power source, attenuate harmonics and deliver dc voltage proportional to incident RF to the front-panel meter and potentiometer. Special design of a directional coupler and thermocouple detector help maintain the calibration of the monitors over a long period of time. Once calibrated, a repeatibility of 0.5% can be expected.

Special control circuits protect the test set; indicators assure the operator of proper test set operation and monitor output voltages and current drains. Simple removal of individual rack-mounted units speeds calibration and routine maintenance

Write today for complete information.

SPECIFICATIONS

Frequencies:	30, 100, 300, 400, 500 and 1300 MC
Frequency Accuracy and Stability:	± 0.01%
Power Ranges*:	Six ranges (5, 15, 30, 60, 100 and 125 watts) for five lowest frequencies; four ranges (5, 15, 30 and 60 watts) at 1300 MC; all power levels adjustable by vernier control to at least ± 10% of nominal range. Vernier resolution is greater than 0.25%
Power-Monitoring Accuracy:	± 1% maximum error with potentiometer measurement, and ± 4% (full scale) maximum error with panel-mounted meter. Probable (rms) errors are 0.55% and 2.5%, respectively
Output Impedance:	50 ohms
Recommended Max. Load VSWR:	1.5 to 1
Harmonic Content:	At least 50 db below fundamental frequency
Dimensions:	68″ high, 42.5″ wide, 20″ deep
Price:	$15,000.00

*Internal adjustments allow power ranges to be adjusted to any desired coverage.

Data subject to change without notice. Price f. o. b. factory.

sierra

SIERRA ELECTRONIC CORPORATION
A Division of Philco Corporation
7197C BOHANNON DRIVE • DAVENPORT 6-2060 • AREA CODE 415 • MENLO PARK, CALIF., U. S. A.
Sales representatives in all major areas
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7197

PIONEERING

AT BELL TELEPHONE LABORATORIES

In such an open field as this Dr. Karl Jansky of Bell Laboratories opened the way to radio astronomy. His search for a mysterious source of radio noise led him—and us—to the stars for our answer.

Today Bell scientists continue their pioneering in many fields—among them the transmission of human voices on beams of coherent light. Bell Laboratories' revolutionary Optical Maser foreshadows the use of light as a whole new medium of telephone, TV and data communications.

These are but two of the many fundamental advances which have come from breaking fresh ground at the world center of communications research and development.

American Systems Research and Development Facility in Hawthorne, California.

INTRODUCING

AMERICAN SYSTEMS, INC.

Hawthorne, California

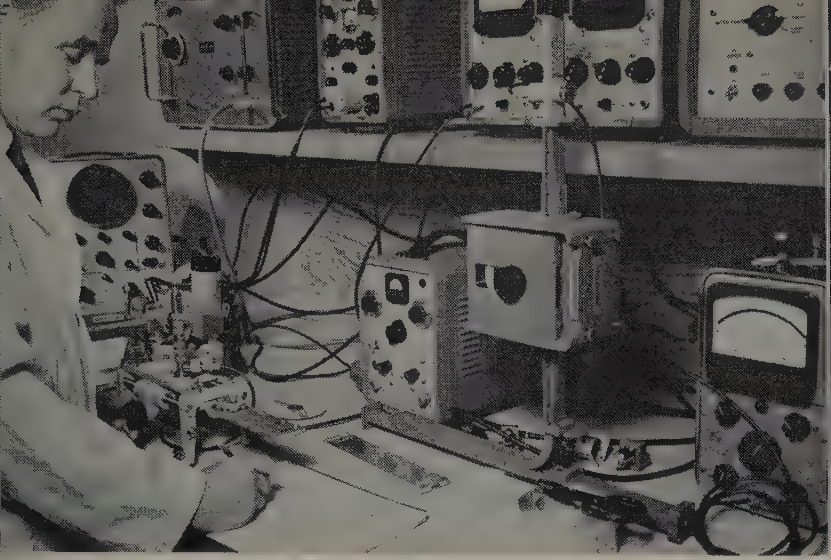
The formation of American Systems Incorporated of Hawthorne, California has been based on one of the primary trends in electronics over the last decade — the emphasis on the "system." Since technology has gradually revealed interrelationships between what once appeared to be separate problems and requirements, it has become increasingly advantageous and economic to integrate tasks into system solutions. Typical of these are military data acquisition-processing-display-command systems such as the Navy NTDS and the Air Force Quick-Globe. Many industrial examples also exist.

In February 1960, American Systems Incorporated was founded for research, development, and production of electronic systems. From the outset, the Corporation was organized for advancement in six major technical areas: electromagnetic systems, information sciences, advanced component development, devices research, instruments, and command and control systems. Key technical and scientific personnel for each of these areas were obtained in the first few months of operation.

These objectives, of course, require a planned, orderly, and stable pattern of growth, which in turn requires appropriate capital resources. These have been supplied by the Schlumberger Well Surveying Corporation of Houston, Texas. This highly successful and stable company, with world-wide interests, was itself the result of originality and initiative in the field of electrical prospecting techniques for oil and minerals. The basic idea of American Systems thus was highly compatible with the Schlumberger approach.

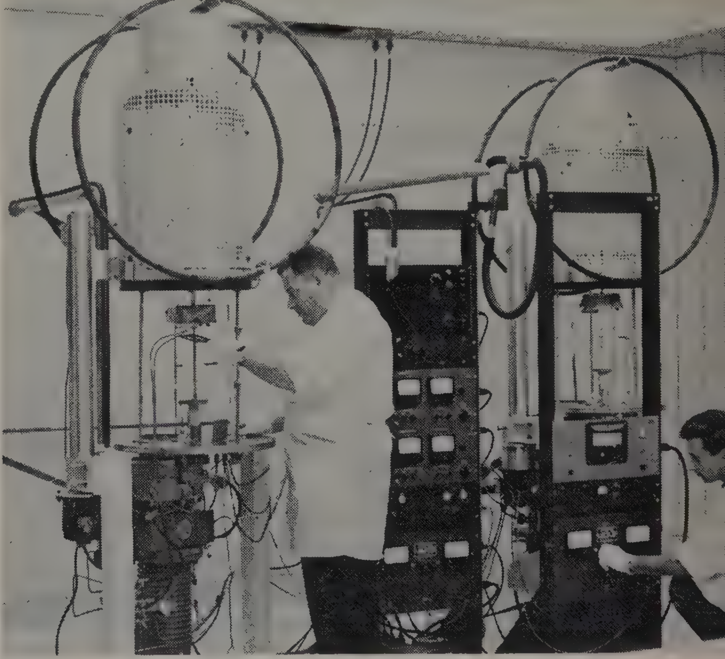
As a result, American Systems was launched with an initial investment by Schlumberger of $1.5 million, and an additional commitment for loan funds of $8.5 million. The common stock representing the Schlumberger interest is held in trust by a Board of Trustees.

(*Continued on page 44*)



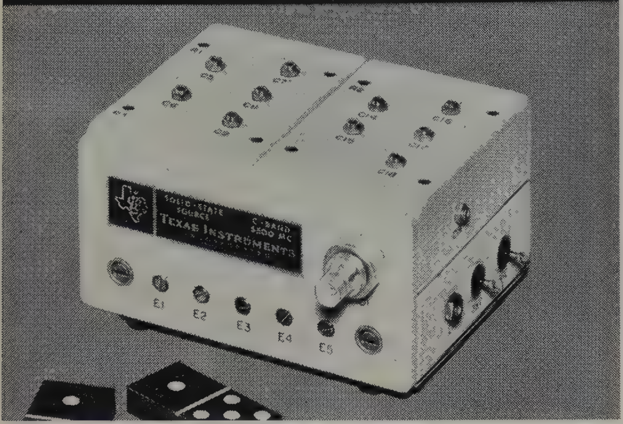
, T. Crail running laboratory tests on a new microwave component. Right, discussing the design of a new digital thin magnetic sorter are, left to right, R. J. Shank, president; Dr. R. E. Fagen, and Dr. R. B. Dawson.

Karnapp in the Air Shower, preparatory to entering the aclean Advanced Devices Laboratory.



Above, M. Braunstein (left) and R. Buchan set up vacuum evaporation equipment in the Devices Research Ultraclean Laboratory. Below, left to right, Dr. M. B. Melillo, D. Di cesare, and M. Matalon run hardness tests on a new magnetic surface.

NEW . . . SOLID-STATE MICROWAVE SOURCES
from 30 mc to 10 kmc!



REPLACE KLYSTRONS IN FIXED-FREQUENCY APPLICATIONS!

Solid-state microwave sources from Texas Instruments now give you a small, light-weight, reliable means of generating crystal-controlled, low-power microwave signals. Designed with TI XD-500 gallium arsenide diodes, these devices can be used wherever reliable, fixed-frequency, r-f sources are needed; for example, local oscillators, parametric amplifier pumps, higher frequency telemetry transmitters, microwave transmitter exciters, laboratory and portable field test signal generators and frequency standards, and phase-locked oscillators. Modular construction lets you add new frequencies by "stacking," or modify frequencies by changing multiplier units. Sources for your special needs can be supplied by modifying standard TI designs.

TYPICAL SOLID-STATE SOURCE CHARACTERISTICS	
frequency accuracy	Crystal, Standard models 0.005%
frequency stability	0.005%
band pass	1% to 5% up to 3 kmc Less than 1% above 3 kmc
spurious frequencies	Down 30-40 db
output impedance	50 ohms
primary power requirements	28 v dc positive; power requirements, 1-20 watts depending on frequency and power output; 28 v regulated power supply operating from 115 v 60 cps or 400 cps can be provided.

Harmonic generators — to frequency multiply existing power outputs to frequencies as high as 20 kmc — are also available. For details on TI's Solid-state microwave sources and harmonic generators, write for Bulletin No. DLA-1218. For information on other microwave devices contact MARKETING DEPARTMENT.

APPARATUS DIVISION
TEXAS INSTRUMENTS
INCORPORATED
P. O. BOX 6015
DALLAS 22, TEXAS

AMERICAN SYSTEMS

(*Continued from page 42*)

The founders of the Corporation have been active in the electronics field since its early days prior to World War II. Mr. R. J. Shank, president, was previously a vice president of Hughes Aircraft Company, in charge of systems management. In addition to his executive responsibilities for American Systems, he is active in a consulting capacity to the Department of Defense as a member of the Scientific Advisory Board of the Chief of Staff, USAF, and consultant to the Technical Advisory Panel on Electronics, Office of the Secretary of Defense.

American Systems has two vice presidents, Mr. D. S. Barlow and Mr. H. B. Dickinson. Mr. Barlow was also previously with Hughes in a number of top executive responsibilities, including technical director of the Systems Management Office, director of the Industrial Systems Division, and director of Engineering for the Ground Systems Group. Mr. Dickinson, before joining American Systems, was director of the Advanced Electronic Data Laboratory of Consolidated Electrodynamics Corporation, and prior to this assistant to the President of the Corporation.

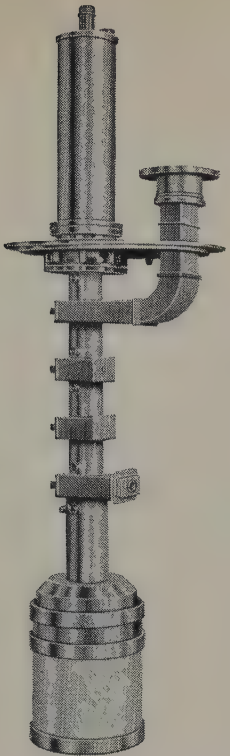
Although in existence only a year, the company has enjoyed a rapid growth. Personnel now number 80, which is an increase of 100 percent since October 1960. In this same period of time, floor space under roof has more than doubled. Operations were started in a leased facility and are now being conducted in a 28,000-square-foot plant built by the Corporation on its own 13-acre site in Hawthorne, California. This site will amply accommodate continued plant expansion to several hundred thousand square feet. Ultimate plans for growth include a large integrated research, development, and manufacturing site, and 400 acres of land have been purchased by Schlumberger on the El Toro ranch area in suburban Los Angeles.

The Electromagnetic Systems Division, directed by M. D. Adcock, previously manager of the Hughes Microwave Laboratory, is currently doing high-level studies in plasma radiation and pattern measurement techniques for large space-track antennas. These techniques are based on original work in the field of time domain radiation done by Dr. R. W. Bickmore and H. E. Shanks, both of whom are with American Systems. New hardware developments are also under way, such as passive reflectors for augmentation of radar returns from targets such as small aircraft. Considerable progress has been made in obtaining coded returns from these devices for aircraft identification.

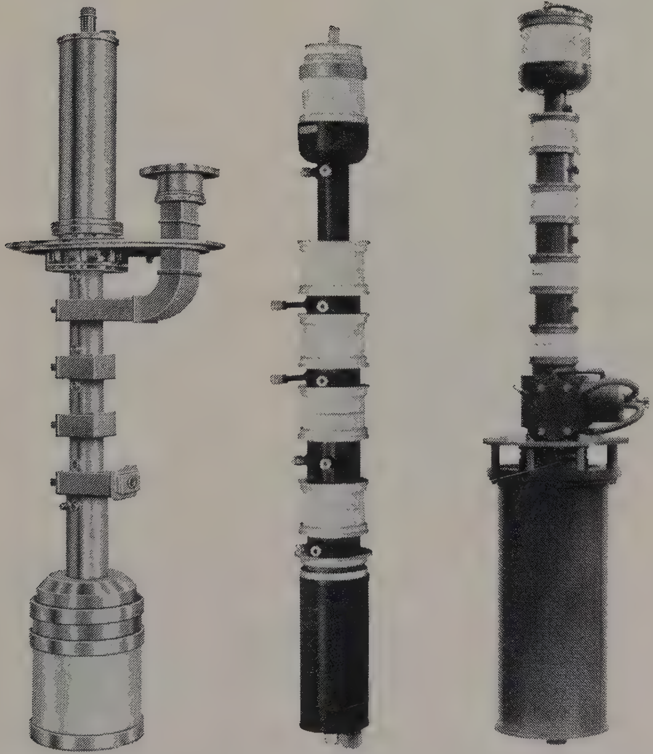
Complementing American Systems capability in the field of electromagnetic data acquisition, the Information Sciences Division, under Dr. R. E. Fagen, is concerned with the problems of digital data processing and computation. This Division is concerned with how computers are logically organized and how they can be used efficiently to perform tasks within a larger system. A significant aspect of this work is creative computer programming, and the Division has completed a number of contracts for programming and computation on large machine

(*Continued on page 46*)

Circle Reader Service Card 26



Most companies think there's only one way to design a klystron.



But Eimac knows there are three.

ome rf ranges and requirements call for an internal cavity klystron. Others, an external one. For still thers, a combined internal-and-external cavity is best. That's why Eimac designs klystrons *all three ways.* And why it has more high power klystrons operating throughout the free world than all other akers combined.) Fact is, that's how Eimac designs *every* tube: to meet your specific needs.

r data on Eimac klystrons shown above (4KP40,000SQ, internal cavity; 4K50,000LQ, external cavity; 5K210,000LQ, combined internal-d-external cavity) contact your Eimac representative or write: Power Klystron Division, Eitel-McCullough, Inc., San Carlos, Calif.

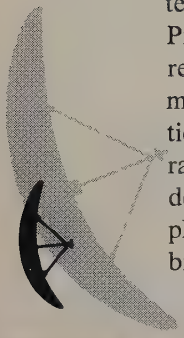
Eimac

Circle Reader Service Card 27

LEL'S NEW PARAMP

SHORTENS THE MILES, BROADENS THE COVERAGE, STRENGTHENS THE SIGNALS

An outstanding state-of-the-art advancement in low-noise receiving systems, the new model RA-1 Telemetry Preamplifier is the first of a series of reactance amplifiers designed for telemetry, space and scatter communications, long range and early warning radar applications. Featuring a high degree of stability, the unit is completely weatherproofed for dependability in all outdoor environments . .



PARAMETRIC
Telemetry Preamplifier

SPECIFICATIONS:

Passband 225-260mc
Gain 25db
Noise Figure 1-2db
Load Impedance .... 50 ohms
Power Input .... 115v, 60cps.

LEL INC.
Akron Street
Copiague, L. I., N. Y.
AMityville 4-2200

Circle Reader Service Card 28

AMERICAN SYSTEMS

(*Continued from page 44*)

installations such as the IBM 709. At present, work is proceeding on a contract for development of automatic programming techniques.

The areas of advanced component development and devices research have undergone recent expansion at American Systems. A proprietary technique for depositing magnetic surfaces on memory drums, disks, and rods is in the pilot production stage. This process, which is completely chemical (catalytic), provides a surface which is extremely uniform and metallurgically hard.

Work is also going forward in the applications of extremely thin magnetic films deposited by vacuum techniques. For this work the Corporation has set up a large ultraclean (dust free) laboratory, with equipment and facilities equivalent to the finest in the field.

Among the key personnel in these fields are Mr. B. Diener, director of the Components Development Division and previously manager of the Displays Project Department at Hughes Ground Systems; Dr. M. B. Melillo, manager of the Magnetic Components Laboratory and previously chief chemist of the Electrada Corporation; Mr. A. Vance, director of the Research Laboratories and previously head of Hughes Information Processing Research Department; Mr. K. D. Broadbent, director of the Solid-State Physics Laboratory and well known innovator in the thin magnetic film field; and Mr. J. W. Bozeman, director of the Command and Control System Division.

Continually expanding the variety and depth of its capabilities has been the key to the American Systems approach. In January of this year, the Corporation acquired the Instrument Division of Micro-Path, Inc. This Division has been engaged in the development and production of an exclusive line of gas sensing devices which perform a variety of functions, including detection of trace quantities of highly toxic missile fuels. This acquisition gives American Systems a unique sensor for electronic monitoring systems at missile installations and industrial plants. The new Division is directed by Mr. L. M. Ballard, previously president of Micro-Path, Inc.

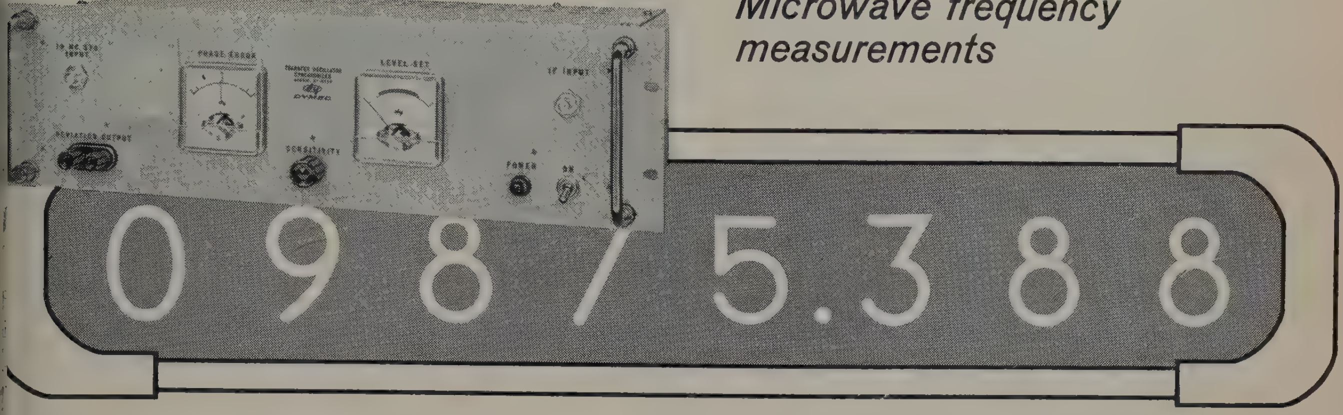
While technical operations are presently centered in Hawthorne, California, the Corporation has an office in Washington, D.C. for marketing and technical liaison. In addition, projects are actively under way with other Schlumberger affiliates in the electronic and technical systems fields. These include the Ridgefield Instrument Group, Ridgefield, Connecticut, which has developed and is manufacturing a unique nuclear magnetic resonance spectrometer; Electro-Mechanical Research, Inc., Sarasota, Florida, makers of telemetering equipment and flight test electronic components; and Computer Systems, Inc., Monmouth Junction, New Jersey, which designs and produces advanced analog computers.

In these diverse activities, the total amount of American Systems' firm business under contract and expected for 1961 is nearly $1.5 million. Present trends indicate that this figure may double in 1962. It is American Systems feeling that the trend toward a technology dominated by the systems concept has only begun. On this point, R. J. Shank wrote in 1960 ". . . . the period in which we live may well be called, by a future historian, the beginning of the systems age."

MEASURE FREQUENCY, 200 MC to 12.4 GC,

with COUNTER ACCURACY!

Faster
More accurate
More useful
Microwave frequency
measurements



ntroduce counter accuracy to your microwave frequency easurements with the unique Dymec Transfer Oscillator ynchronizer! Model DY-5796, used with a Hewlett-Packard ransfer Oscillator and an hp Counter, permits high- ccuracy automatic frequency measurements, even on arying signals, all the way to 12.4 GC.

ith the hp 540A/B Transfer Oscillator and hp 524/525B requency Counter, the DY-5796 Synchronizer provides pos- ive locking of the transfer oscillator to the signal fre- uency . . . thus giving you measurement accuracy equal that of the counter time base. Higher accuracies can be chieved with an external frequency standard, such as the Model 103A Quartz Oscillator, which provides short term tability better than 5 parts in 10^{10}. The hp 524C and 525B requency Converter covers 100 to 220 MC, and the hp 540A ith external hp 934A Harmonic Mixer) or 540B (with the ixer built in) extends your measuring range to 12.4 GC.

y keeping the transfer oscillator and the signal frequency n permanent synchronization, the DY-5796 also permits ong term measurements of low drift rates at microwave equencies. FM deviations up to 0.2% of the carrier fre- uency can be measured with the addition of a VTVM and/ r oscilloscope. Further, this instrument and the associated quipment greatly simplify determination of the harmonic umber and microwave frequency.

he DY-5796 Synchronizer is available from Dymec for use ith your present hp Transfer Oscillator* and Counter—or ou can use the Dymec 5854 Frequency Measuring System omposed of the Synchronizer and the optimum related equipment mounted in only 52½" of rack space.

SPECIFICATIONS

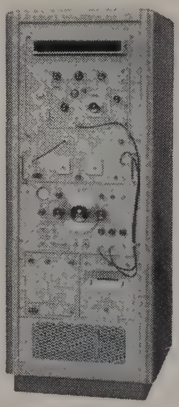
DY-5796 Transfer Oscillator Synchronizer

Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum*
Price:	$685.00

*With Modification Kit 9200-0028 for 540A/B Oscillator. $65.00

DY-5854 Frequency Measuring System

Includes synchronizer, modified transfer oscillator, electronic counter with frequency converter, digital recorder with analog output, cabinet and interconnecting cables.



Frequency Range:	200 MC to 12.4 GC
Lock-on Range:	± 0.2% of signal frequency, maximum
Accuracy:	± 1 count ± stability
Stability:	$3/10^8$ short term, $5/10^8$ per week with 524C/D internal time base. May be used with external frequency standard, e.g., hp 103AR, for greater accuracy.
Registration:	9 places: first 2 on converter dial, next 7 on counter.
Printout:	Full readout of counter printed on paper tape.
Analog Output:	For Potentiometer Recorder: 0-100 mv. Minimum load resistance 0.5M. Calibrate control. For Galvanometer Recorder: 0-1 ma into 5000 ohms or less. Zero and calibrate controls.
FM Measurement:	Deviations up to 0.2% of signal frequency at rates to 1 kc. Above 1 kc, max. deviation limit reduced at 20 db/decade to max. of 0.001% at 200 kc.
Price:	$6,405.00.

Data subject to change without notice. Prices f.o.b. factory.

Write to your Dymec/Hewlett-Packard representative or contact us directly for complete information.

DYMEC
A division of HEWLETT-PACKARD COMPANY

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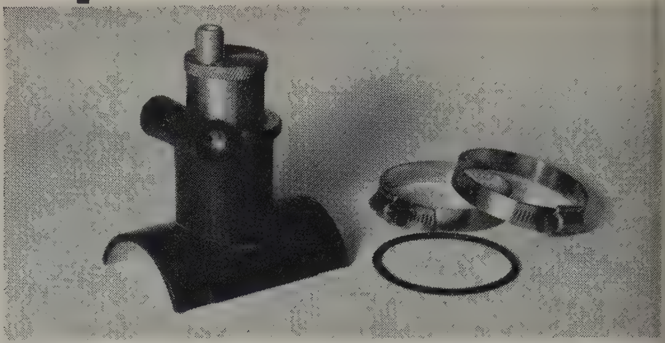
7204

Directional Couplers

with adjustable rf output for rigid coaxial lines and waveguide



- Pressurized and weatherproof
- Easy to install
- Penetration and angle scales for easy coupling adjustment
- Output source impedance matched to connecting cable

By providing an adjustable coupling to external measuring and monitoring equipment, directional couplers by Dielectric facilitate tuning, operating, and maintenance measurements on r-f transmitters, directing and controlling devices, transmission lines, and antenna feed systems. Depending only on the angular orientation, either the incident or the reflected wave may be sampled. Reflectometers for VSWR and net power output measurements require two couplers, one for sampling the incident, the other for sampling the reflected wave.

The r-f output of all Dielectric couplers is directly proportional to line power level at a fixed frequency, and the coupling ratio has a slope of 6 db/octave as frequency is changed. However, compensating networks to maintain the coupler output flat over a specified frequency range can be provided.

Standard couplers for 3⅛″ and larger coaxial lines are suitable for any power level and coupling ratio up to four watts coupler output, couplers for smaller lines are limited to one watt output. Waveguide couplers for 1½″ x 3″ and larger waveguide provide up to 2 watts output, couplers for smaller guide are limited to one watt.

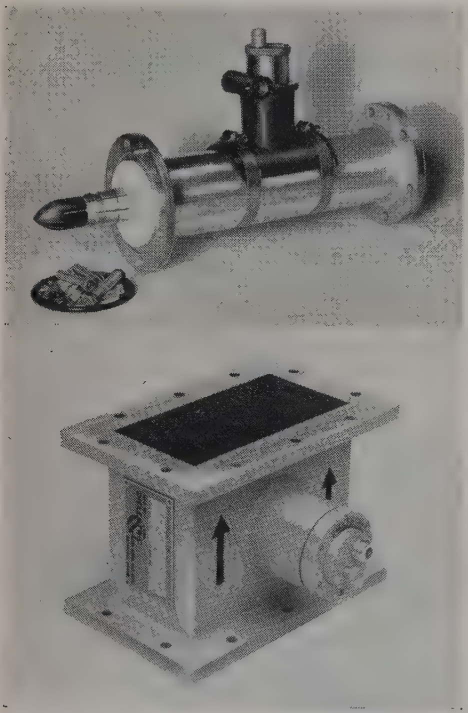
When a d-c output is required, a crystal detector can be supplied for direct attachment to the output jack. A unit comprising a d-c microammeter, reversing and range switches, and variable resistors for calibration is also available.

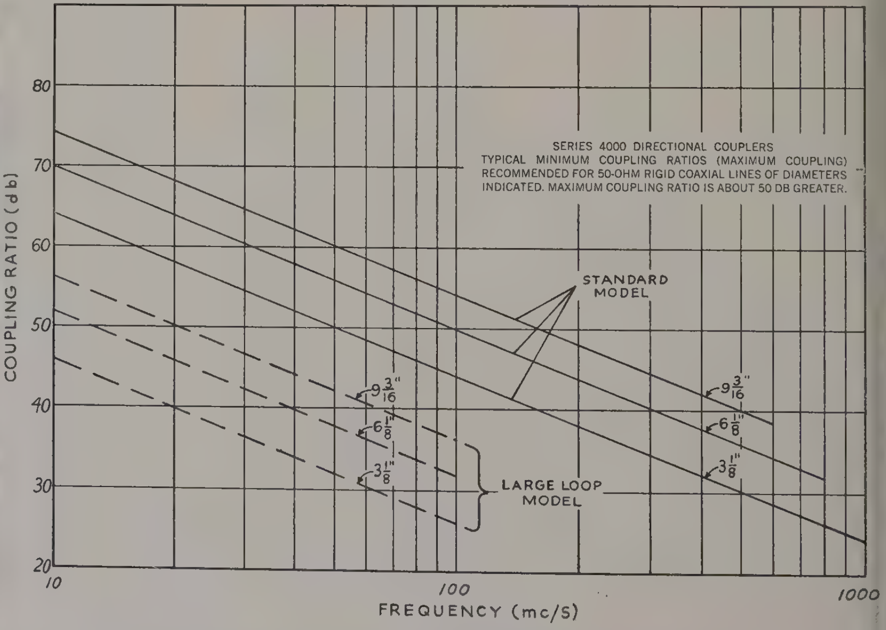
The VSWR caused by a coupler is small, and a direct function of penetration (coupling). At very high coupling ratios, the perturbation is almost unreadable. At maximum recommended coupling, VSWR is less than 1.03.

Directivity of standard models is not less than 30 db. On special order, models having a directivity of not less than 40 db will be supplied. The range of coupling ratio is roughly 30 to 80 db, depending on model and frequency.

For further information ask for our directional coupler bulletins. For the answer to specific questions or about special designs, write or call our PROPOSAL ENGINEERING DEPARTMENT.

*For applications in the public entertainment field, DIELECTRIC products are available from the Radio Corporation of America. For all other applications, contact DIELECTRIC directly.




SERIES 4000 DIRECTIONAL COUPLERS
TYPICAL MINIMUM COUPLING RATIOS (MAXIMUM COUPLING) RECOMMENDED FOR 50-OHM RIGID COAXIAL LINES OF DIAMETERS INDICATED. MAXIMUM COUPLING RATIO IS ABOUT 50 DB GREATER.
COUPLING RATIO (db)
80
70
60
50
40
30
20
10
100
1000
FREQUENCY (mc/S)
STANDARD MODEL
LARGE LOOP MODEL
9 3/16"
6 1/8"
3 1/8"
9 3/16"
6 1/8"
3 1/8"

DIELECTRIC'S areas of capability include coaxial, waveguide and open wire techniques . . .

TRANSMISSION LINES & COMPONENTS • NETWORKS

SWITCHES • ANTENNAS & FEEDS • TEST EQUIPMENT • R & D ENGINEERING

dial DIELECTRIC
for solutions to
communications
problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

Circle Reader Service Card 30

(*Continued from page 34*)

RADAR SCIENTIST JOINS HUGHES

Dr. Raymond DuHamel has joined Iughes Aircraft Company's ground systems roup, Fullerton, Cal., as a senior staff cientist in the radar laboratory, Dr. Nicholas A. Begovich, vice president and ssistant group executive has announced. Dr. DuHamel will report to Dr. Nicholas Yaru, associate manager, radar laboratory.

Before joining Hughes, Dr. DuHamel erved as assistant director of the research livision, Collins Radio Co., Cedar Rapids, owa. He has had 14 years experience in he field of antennas and holds several patents, with others pending, for his work n log periodic antennas.

Dr. DuHamel is a member of the Instiute of Radio Engineers' Professional Group n Antennas and Propagation, and Profesional Group on Microwave Theory and Techniques.

—*mwj*—

VARIAN EXECUTIVE HONORED

Edward W. Herold, vice president, reearch, at Varian Associates, Palo Alto, Cal., has received n honorary degree f Doctor of Sciince from Polytechic Institute of Brooklyn.

The degree, conerred by the Instiute upon a limited number of men of minent achievenent, is in recogniion of Mr. Herold's "distinguished accomplishments in he field of electron devices and solid tate devices."

In addition to receiving the degree, Mr. Herold delivered the commencement adlress for the Institute's 106th annual ommencement exercise.

—*mwj*—

ANTENNA SYSTEMS FORMS PACIFIC DIVISION

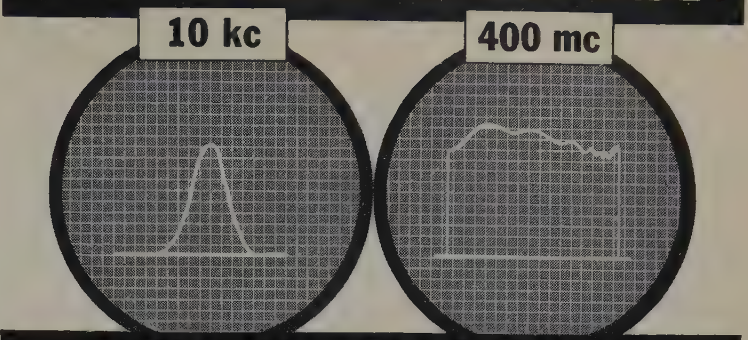
Antenna Systems, Inc., Hingham, Mass., nnounces it has formed the Pacific Diviion — a new western division located in National City, Cal., (San Diego).

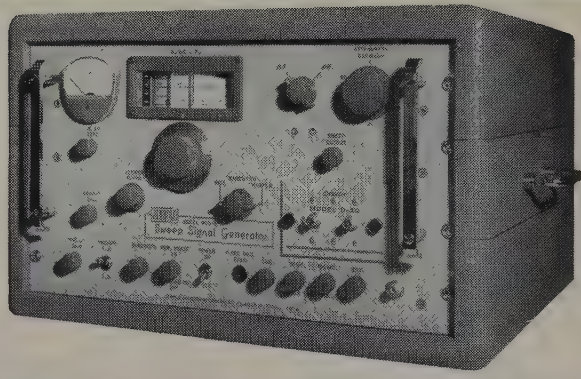
The division will have all the facilities necessary to offer a complete antenna service including design construction and intallation of antennas in the field of catter communications, missile tracking, adar, and radio astronomy. Special emphasis will initially be given to large rackers. It will also maintain a stock of ASI waveguide components.

ASI, Pacific Division, will be headed by Kendrick H. Lippitt.

—*mwj*—

(*Continued on page 50*)





VERY NARROW TO VERY WIDE
10 kc
400 mc
SWEEP WIDTHS*
...ALL IN ONE INSTRUMENT

NEW JERROLD® 900B
SWEEP SIGNAL GENERATOR

Here's the last word in versatility and precision, the ultimate instrument for all your IF-VHF-UHF requirements. The new Jerrold 900B offers unusual stability in sweep widths as narrow as 10 kc and as wide as 400 mc. Frequency range 500 kc to 1200 mc.

$1980.00 f.o.b. Philadelphia**

*Illustration of scope at left shows typical communications receiver response 4 kc bandwidth at 7 mc. Illustration at right shows typical distributed amplifier response 2-220 mc.

***Prices and specifications subject to change without notice.*

- Built-in crystal-controlled harmonic markers at 1, 10, and 100mc intervals.
- Each marker output individually controls from front panel.
- Built-in variable-gain dc-coupled scope preamplifier with 200X gain.
- Built-in precision attenuator from zero to 50db in 10db steps.
- Accurately calibrated frequency dial.
- High-level metered output.

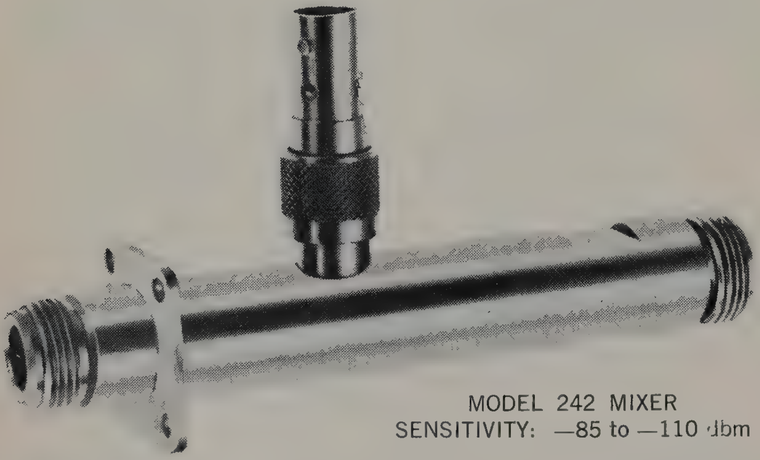
Write for complete technical data.

JERROLD® ELECTRONICS CORPORATION
Industrial Products Division, Dept. ITE-102
The Jerrold Building, Philadelphia 32, Pa.

Jerrold Electronics (Canada) Ltd., Toronto •
Export Representative: Rocke International, New York 16, N.Y.

Circle Reader Service Card 31

HOW SENSITIVE CAN ONE BE?



MODEL 242 MIXER
SENSITIVITY: —85 to —110 dbm

Sage Laboratories Model 242 Single Ended Mixer is a sensitive one, indeed. Over the frequency range from 10 mc to 15,000 mc, the sensitivity ranges from —85 dbm to —110 dbm with an average of approximately —90 dbm. For narrow band applications, sensitivities in excess of —120 dbm have consistently been achieved.

Every unit is factory tested at five frequencies using a 1N358A crystal. The measurements are made with a 2 mc IF bandwidth centered at 30 mc. LO power required is between 2 and 10 mw. The lowest crystal current corresponding to linear mixing is approximately 0.2 ma.

Unit price with 1N358A crystal is $125.00. Unit price without crystal is $100.00.

SAGE LABORATORIES, INC.
3 Huron Drive • East Natick Industrial Park • Natick, Massachusetts

Circle Reader Service Card 32

Industry News

(*Continued from page 49*)

MICROWAVE BEAM SPANS 136 MILES

The world's longest point-to-point microwave beam for television relay service has begun carrying programs 136 miles in a line of sight between mountain peak relay stations in the Idaho-Utah border area, it has been announced by C. H. Colledge, division vice president and general manager of RCA's Broadcast and Television Equipment Division.

Mr. Colledge said the system relays network programs from a 9,000-foot peak near Salt Lake City across the length of Great Salt Lake and through a mountain pass to a receiving point on Albion Peak in Idaho. From there, a connecting microwave link flashes the signal to the transmitter site of Station KID-TV, Idaho Falls.

The technical achievement represented by the long microwave hop has resulted in a clearer incoming TV signal at the transmitter, providing KID-TV viewers with markedly-improved reception of network shows on their home screens, he pointed out.

The system makes use of RCA's new TVM-1B microwave relay equipment which was designed for the transmission of television programs in both black-and-white and color.

The microwave link was engineered by RCA specialists working in conjunction with the engineering staff of KID-TV and under the direction of Melvin B. Wright, President, Skyline Advertising and Sales, Inc.

—mwj—

PHILCO CHOOSES VICE PRESIDENT OF GOVERNMENT/INDUSTRIAL DIVISION

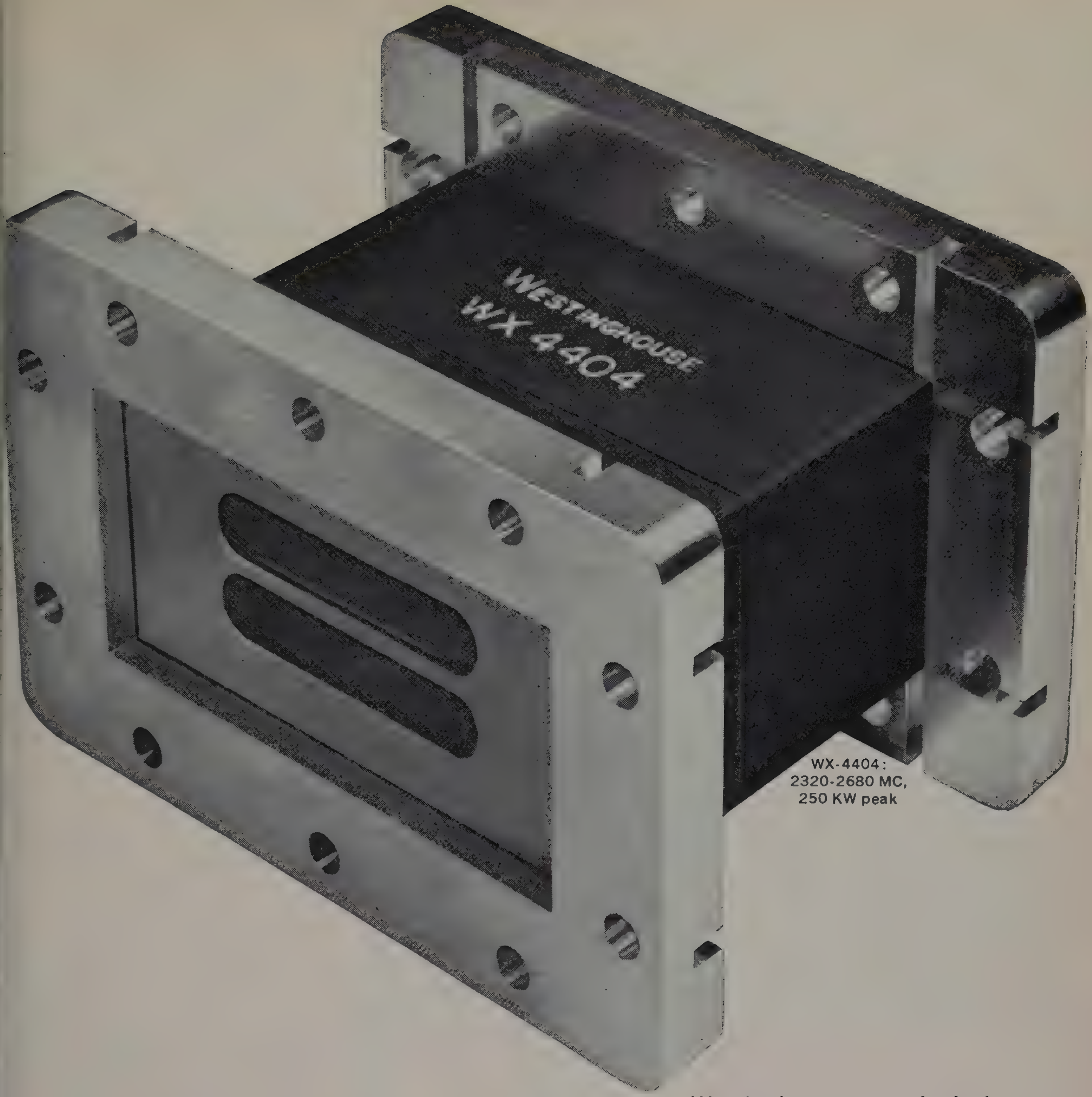
H. Edward Rice has been named vice president-operations of Philco Corporation's Government and Industrial Group headquarters, Philadelphia, Pa.

According to Henry F. Argento, vice president and general manager of the G&I Group, Mr. Rice will coördinate the manufacturing operations of the Group's five divisions. They include the Computer, Communications and Weapons, and Communications Systems Divisions in the Philadelphia area, and, in California, the Sierra Electronic Division and the company's space and satellite laboratory, Western Development Laboratories.

Prior to joining Philco, Mr. Rice was manager of manufacturing for the General Electric Company's Light Military Electronics Department in Utica, N.Y.

—mwj—

(*Continued on page 52*)



WX-4404:
2320-2680 MC,
250 KW peak

Westinghouse extends design capabilities for **switching tubes.** Difficult switch tube or device problems can be solved by experienced Westinghouse engineers who are system design oriented. For example: To protect a low noise S-Band traveling-wave tube from 250 KW peak power at 1 KW average without serious degradation of noise figure—Westinghouse developed the WX-4404 pre-TR tube with a maximum insertions loss of 0.2 db. Power incident on the TWT is reduced to less than 100 watts peak. Other example: To protect the receiver of a C-band pulse doppler radar employing a ferrite circulator from transmitter power up to 1 KW peak power and 100 W average power reflected from the antenna without degrading system performance—Westinghouse developed the WX-4405 crystal protector with a maximum recovery time of 0.2 microseconds. Crystal receiver is protected at power levels from zero to 1 KW peak. What about your problem? Write on your company letterhead to: Westinghouse Electric Corporation, Elmira, N.Y. You can be sure . . . if it's Westinghouse.

Westinghouse

Circle Reader Service Card 33

KEARFOTT MICROWAVE ANTENNAS

1. **X-BAND MONO PULSE ANTENNA** utilizes the principle of multiple modes in waveguide. It features extremely deep mulls (50 DB) and a very compact configuration.
2. **PARABOLIC ANTENNAS** of conventional design for X-Band and KU-Band are also available in the Kearfott line.
3. **HORN ANTENNA** This dielectric lense horn antenna is phase compensated to give optimum patterns and side lobe levels.
4. **X-BAND PLANAR ARRAY ANTENNA** consists of a phased array of waveguide slot radiators. The pattern consists of two conical beams at a carefully controlled angle with respect to vertical.
5. **K_a BAND CONICAL SCANNING ANTENNA** achieves a high rate of electrical scanning through use of a tri-slot device that gives 3 electrical scans for each mechanical scan. Compactly designed, it provides extremely close control (less than .1 DB) over the cross over.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Circle Reader Service Card 34

Industry News

(Continued from page 50)

FELDMANN ELECTED TO BOARD OF AMPHENOL-BORG

Henry Feldmann, president of FXR, Inc., Woodside, N.Y., manufacturer of microwave test instruments and equipment, has been elected to the board of directors of Amphenol-Borg Electronics Corp. following the merger of FXR and Amphenol - Borg. FXR becomes an Amphenol - Borg division with Mr. Feldmann continuing as its operating head.

Mr. Feldmann was trained as a toolmaker in the old-school machine shops of Germany and after serving as plant superintendent for a leading industrial firm came to the United States in 1927. He worked in a supervisory capacity for Westinghouse Electric & Manufacturing Co. before forming FXR in 1944.

Mr. Feldmann has personally directed operations of the company since its inception, except for a brief period of ill health last year.

—mwj—

NEW FACILITY OPENED BY SANDERS ASSOCIATES

As part of its intensive expansion program, Sanders Associates, Inc., Plainview, N.Y., active in the design and development of electronic systems, precision electro-mechanical components, and process components, has recently opened a new facility at Plainview, Long Island. The facility will be primarily engaged in the development and production of electronic ground support equipment.

This is the second big expansion by Sanders within the past six months. In the fall of 1960, Sanders opened a new facility at Burlington, Mass. to carry on research and development.

The new facility at Plainview, which opened last December, has a plant space of approximately 50,000 square feet, and is presently staffed by slightly more than 100 employees, the majority of whom are engineering and engineering service personnel. The facility will be primarily engaged in the design, development and manufacture of ground support equipment for airborne electronic systems.

At present, work is being done on the development of electronic test equipment for shop, line, and pre-flight testing of various airborne electronic systems developed and manufactured for the armed services by Sanders Associates.

—mwj—

SAPPHIRES TO PROTECT PHONE ATELLITES FROM SPACE HAZARDS

Thousands of pieces of man-made sapphire ll cover the surface of the communications satellites now being developed by Bell elephone Laboratories, New York, N. Y., e company's president, Dr. James B. Fisk, s announced.

The sapphires are expected to protect lar cells from space radiation, enabling working" telephone satellites to endure e rigors of space for 10 years or more.

Dr. Fisk cited the sapphire protection an example of thorough-going measures at are being taken to achieve long-life tellite reliability. Bell Laboratories is using approach it evolved in developing submarine cable systems. Some 1500 electron bes have functioned under the oceans for e past two to six years without a failure.

"Now the exacting methods that produced extremely reliable submarine cable stems are being applied to satellites," he id. "The result should be a shipshape, spaceworthy communications relay station."

—mwj—

MADIGAN ELECTRONIC REORGANIZES TO CONCENTRATE ON BASIC RESEARCH

Following a trend being adopted by everal electronics companies, Madigan lectronic Corp., Carle Place, Long Island, has totally reorganized in order to oncentrate on research, development and ystems management, it has been announced by William J. Madigan, chairman f the board.

One of the principle changes in reshaping the 14-year old company is the ormation of a Molecular Electronics Division, which will conduct company-financed research in molecular and solid tate electronics, electroluminescence and hin films.

This will give Madigan four operating ivisions — a Florida division at Orlando or the development of military electronic ardware; an engineering division at Carle Place conducting research and development in systems and subsystems for military and commercial application; an engineering technical service division at Carle Place, with engineering field teams at over 40 locations in the U. S. and overseas bases; and the Molecular Electronics Division.

The new Molecular Electronics Division s headed by Donald Arany as divisional vice president-manager. Mr. Arany has 20 years of experience as an electronics and research engineer. He has been associated with the development of the radar system used in the Grumman W2F aircraft, an Air Force electronic receiver reconnaissance system, the Mark 12 IFF System and several other well-known military electronics systems.

—mwj—

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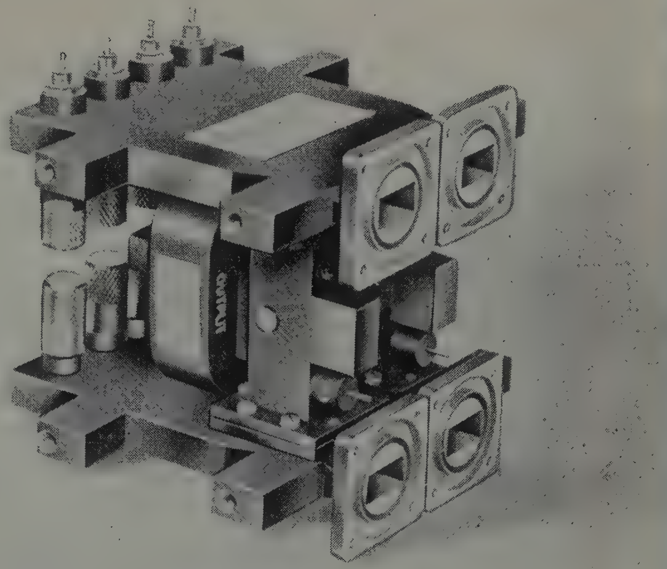
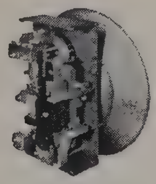


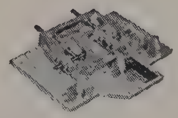
PACKAGED PRECISION
FOR YOUR EXACT REQUIREMENTS

MICROWAVE SUB-SYSTEMS

Kearfott has the experience and ability to design precision sub-systems to the customer's actual configuration and performance needs. The availability of a wide variety of standard components, coupled with advanced techniques, makes it possible to provide packaged r-f assemblies with a high component density—tailored to precise volumetric specifications. For minimum size and weight in airborne or missile applications — for military system environment—Kearfott will successfully design your sub-system —to your most exacting requirement.

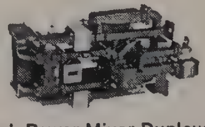


Mono-Pulse Radar



S-Band Strip-transmission Head

Mixer Duplexer



High Power Mixer Duplexer

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

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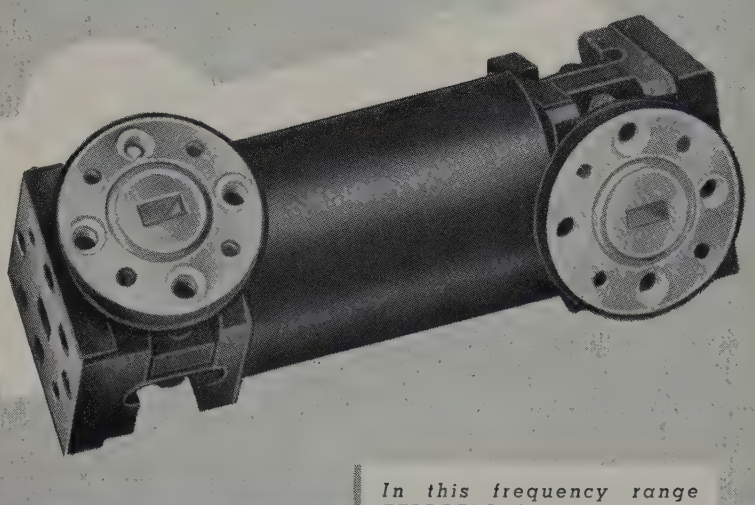
FERROTEC

Extends its

MILLIMETER FERRITE DEVICES



In this frequency range FERROTEC has a complete line of:

- CIRCULATORS
- ISOLATORS
- MODULATORS
- SWITCHES

Because of the low field necessary exceptionally high switching speeds can be attained. A sampling of typical units is tabulated below.

CIRCULATOR SWITCHES

MODEL	f_o (KMC)	BAND-WIDTH (MIN)
R-227LS	70	5%
T-153L*	70	3%
R-330L	67	6%
R-307LS	52.5	6%
R-300LS	35	6%
R-214LS	24	6%

**Junction Circulator*
Data sheets available on request.

FERROTEC has the most complete line of ferrite devices in the industry — extending from 250MC to 75,000MC.

Contact your local sales representative or write to:

FERROTEC INC.

217 CALIFORNIA STREET • NEWTON 58, MASSACHUSETTS

Circle Reader Service Card 36

Industry News

(*Continued from page 53*)

SPERRY GRANTED CONTRACT TO UPDATE ATLANTIC MISSILE RANGE

Sperry Rand Corp., New York, N.Y., was named as prime contractor of a U.S. Air Force contract toward modernization and expansion of the Atlantic Missile Range.

The contract, which calls for the conversion of two 11,000 ton troop carrier ships into mobile missile-tracking stations, is a part of a $60 million program to modernize the instrumentation and data acquisition facilities of the Atlantic Missile Range in support of launchings from Cape Canaveral, Fla.

Dr. L. L. Wheeler, manager of the Systems Group and vice president for engineering at Sperry Gyroscope Co., said that conversion of the two C-4 vessels is planned to be accomplished by a team that also includes: Gibbs & Cox, Inc., New York, N.Y. — naval architecture; Ford Instrument Co., Long Island City, N.Y. — data handling and optical systems; Remington Rand UNIVAC, Division of Sperry Rand Corp., St. Paul, Minn. — data handling; American Optical Co., subsidiary J. W. Fecker, Pittsburgh, Pa. — optical systems; IT&T Laboratories, International Telephone and Telegraph Corp., Nutley, N.J. — communications, telemetry, timing, data handling; and Bethlehem Steel Corp., Ship-building Division, Brooklyn, N.Y. — ship conversion.

— mwj —

EXPANSION OF RESEARCH FACILITIES PLANNED AT UNIVERSITY OF CALIFORNIA

A major expansion of basic research within the Electronics Research Laboratory at the University of California, Berkeley, will soon take place thanks to a new $250,000 per year contract negotiated between the University and the three armed services.

The agencies sponsoring the program are the Office of Naval Research, the U. S. Army Signal Corps and Army Research Office, and the U. S. Air Force Office of Scientific Research.

Dr. Donald O. Pederson, Director of the Laboratory, indicated that the new contract will serve to strengthen the graduate electronics research and teaching program at Berkeley by providing broad support for most areas of study within the Laboratory.

Some of the principal fields of study to be covered by the new contract will be microwave tube research, solid state electronics, circuit research, and microwave radiation and propagation.

— mwj —

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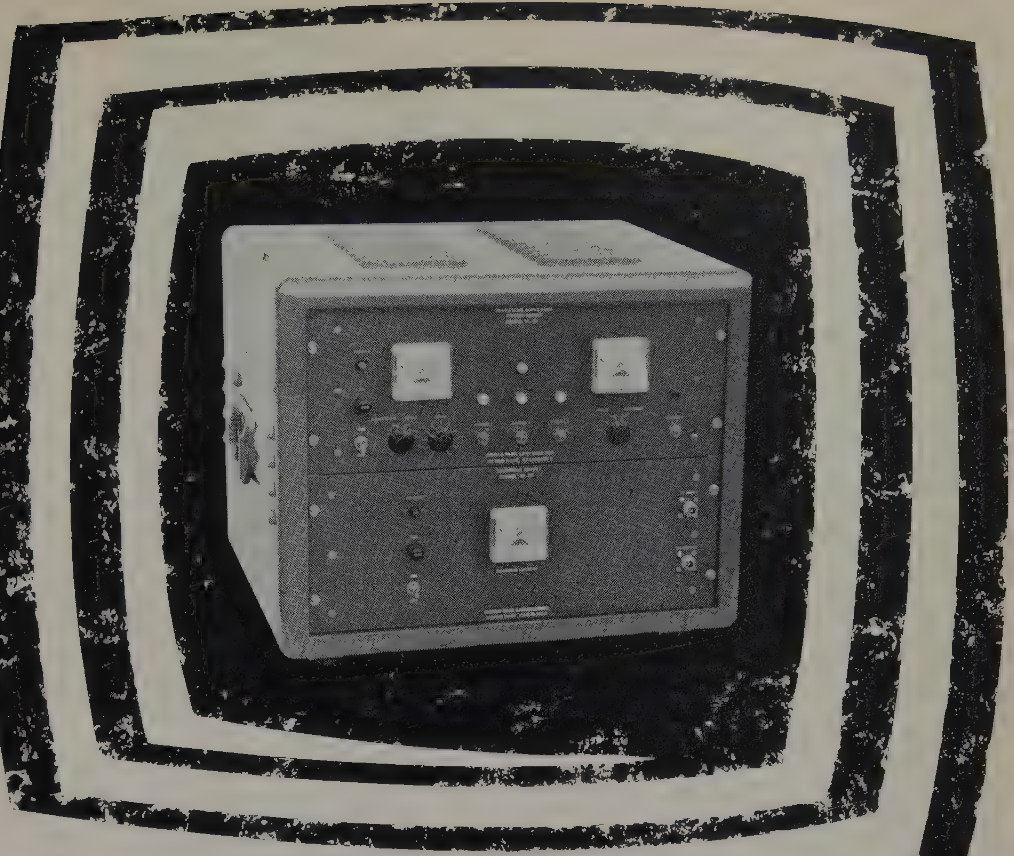

- **Broadband**
- **Crystal Burnout Protection**
- **High Front to Back Ratio**

OW NOISE MICROWAVE PREAMPLIFIERS

Menlo Park Engineering TWT Preamplifiers provide broadband low noise and ultra low noise amplification for applications in radar, tracking countermeasures and communication systems. Units are available utilizing the new PM and PPM low noise TWTs in S, C and X bands, as well as the conventional solenoid focused amplifiers. Ultra low noise units are available in L and S bands. Combinations of preamplifiers will provide complete frequency coverage from 0.5 to 18.0 Kmc.

These amplifiers offer noise figures as low as 7 db in "standard units". Over selected frequency ranges, noise figures of 4.5 db or lower are available on special order.

Ultra stable, low ripple power supplies assure no degradation of microwave tube performance. Remote control features permit operation of TWT, solenoid and solenoid power supply at distances up to 200 feet from the electrode supply. All standard units operate from 115 volts ± 10%, 50/60 cps and are designed for 19" relay rack mounting. Special packaging can be supplied for particular applications.

MENLO PARK ENGINEERING

711 HAMILTON AVENUE MENLO PARK, CALIFORNIA DAvenport 6-9080 TWX PAL AL-110

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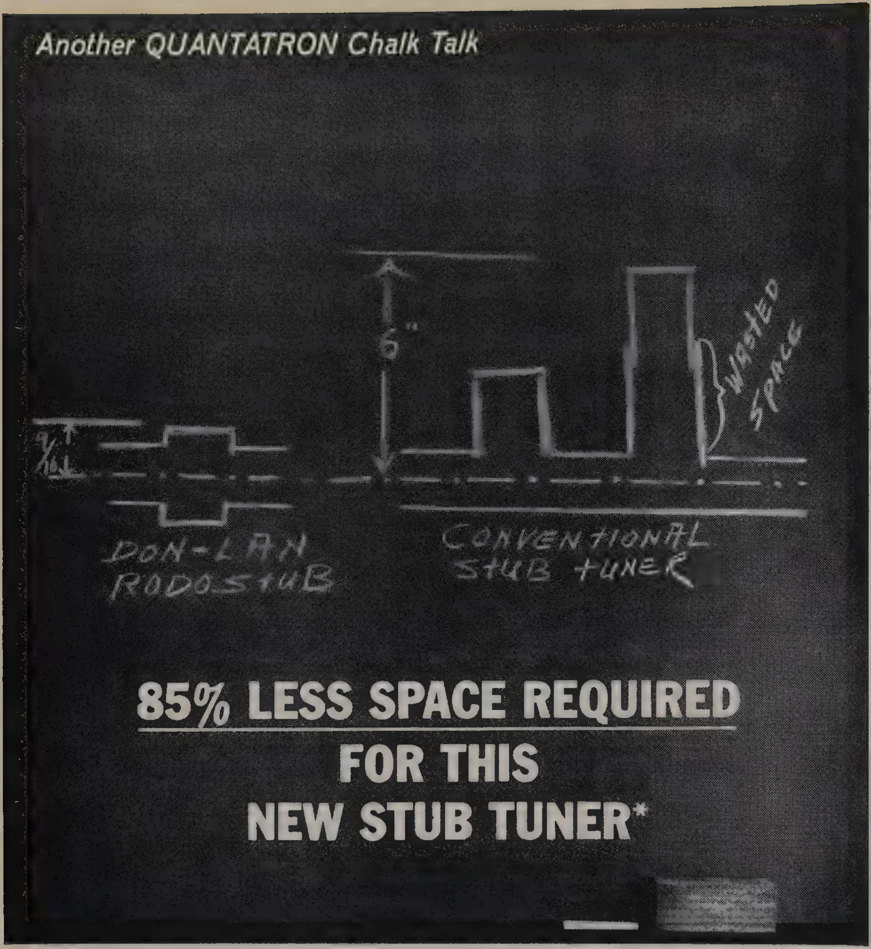
Another QUANTATRON Chalk Talk
6"
9/16"
WASTED SPACE
DON-LAN RODOSTUB
CONVENTIONAL STUB TUNER
85% LESS SPACE REQUIRED FOR THIS NEW STUB TUNER*

RODOSTUB,Ⓣ the new ROtary DOuble STUB calibrated tuner by Don-Lan, makes in-line tunable transmission lines possible. Designed for military environments, the compact RODOSTUB with its firm locking device occupies only 1/6 the space of conventional double stub tuners.

ACTUAL SIZE

Model S-100 RODOSTUB shown here covers 100 to 10,300 mc. Its bigger brother, Model S-200, covers 0.1 to 2.0 gigacycles. Both series feature the unique Don-Lan in-line rugged construction.

RODOSTUB is only one of the unique line of Don-Lan microwave products produced by Quantatron. Write for details. Consult our engineering staff on your microwave requirements.

Quantatron, Inc.
Microwave Laboratories

Quantatron offers its microwave products through its components division... **Don-Lan Electronics, Inc., 1131 Olympic Blvd., Santa Monica, Cal.** *Inquiries from qualified microwave engineers are invited.*

Industry News

(*Continued from page 54*)

HUGE BALL BEARINGS CONSTRUCTED TO SUPPORT RADAR ANTENNAS

Seven huge precision ball bearings, each large enough to fit over a small car, have been made for use in America's latest air defense radar system by The Kaydon Engineering Corp., Muskegon, Mich.

When installed, each of the more than 13-foot diameter bearings support a giant radar antenna almost the width of a football field. Each antenna is built on a concrete tower 85 feet high and 60 feet wide.

The radar system is made by Sperry Gyroscope Co., a division of Sperry Rand Corp., Great Neck, N.Y., for the Air Force. The AN-FPS-35 antennas are part of an electronic defense network of advanced radar stations for guarding against air attack.

Target position data is fed by the radar system into highspeed computers. The computers make the necessary calculations for intercepting and destroying the target with an advanced missile weapon system.

The bearing has four-point contact construction with integral internal gear, mounting flange and mounting holes, and is designed to operate under wide temperature variations for a minimum of 10 years. These bearings are 160-1/2 inches in diameter.

—mwj—

WALDSCHMITT CHOSEN PRESIDENT OF PAGE COMMUNICATIONS ENGINEERS

Election of Joseph A. Waldschmitt as president and chief executive officer of Page Communications Engineers, Inc., Washington, D.C., international communications subsidiary of Northrop Corp., has been announced.

Mr. Waldschmitt, who has been with Page since its founding in 1947, previously was executive vice president. He succeeds Esterly C. Page, who was elected chairman of the board. Mr. Page will devote his full time to the chairmanship.

Creation of the board chairmanship as a full-time assignment was made possible through the resignation from the Page board of Thomas V. Jones, Northrop president, who has completed a two-year term as Chairman of Page. Richard E. Horner, Northrop senior vice president, was elected to the Page board, succeeding Mr. Jones.

Other Page directors are Robert R. Miller, Northrop senior vice president, Dr. William Ballhaus, vice president and general manager of Northrop's Nortronics Division, Mr. Waldschmitt and Mr. Page.

—mwj—

(*Continued on page 60*)

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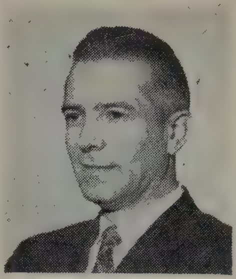
THE MEASUREMENT OF TIME JITTER



by R. G. HEATON

Senior Engineer, Instrumentation Section

LABORATORY FOR ELECTRONICS, INC.

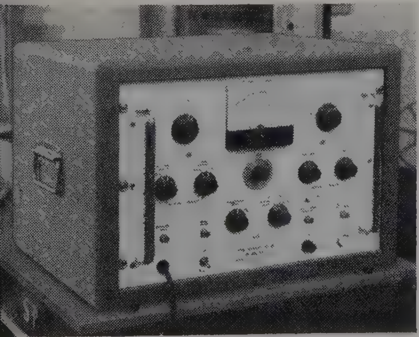
lse-time jitter is variation in the time spacg of pulse edges which results from modution of some form, either cyclic or nonclic. Since timing or synchronizing is an sential process in many electronic devices, me-stability problems occur also. And in ery sophisticated equipment, the specificaons limiting residual time jitter become vere.

me jitter is a common problem in the degn of moving-target-indication (MTI) dars where undesired time modulation may use fixed target pulses to appear as moving rgets, thus causing the loss of ability to stinguish between the two target types. ime jitter may also limit the resolution of nging circuits in fire-control radar systems. n pulse-communications systems, the noise vel may be set by undesired time jitter reulting from noise or hum modulation.

ime jitter often turns up in unexpected laces, hence the need to determine early in design effort whether it exists and from hat cause. For example, a tuning-fork oscilator was once selected as the pulse-repetion-frequency source for a high-performnce MTI system on the assumption that the igh Q of the fork would provide an extra easure of time stability. However, initial hecks by means of a pulse-jitter tester reealed a completely unexpected peak jitter f 0.5 microsecond. The cause: extreme ensitivity to vibration and magnetic fields. The substitution of a simple Hartley oscilator reduced the jitter level below 0.005 microseconds, an improvement of 100:1.

Common causes of cyclic time jitter include hum and ripple modulation from heater and plate voltage supplies, and magnetic field pickup. Cyclic time jitter can be reduced as well as increased as a pulse proceeds through several stages, depending upon the relative phases of the modulation sources; but an increase is the usual case. Common causes of non-cyclic time jitter are noise and microphonic sensitivity to vibration.

Amplitude modulation of a pulse at some point in a circuit frequently leads to time modulation in a later stage of the circuit, and the ability to detect such modulation is helpful in the fault location process. The instrument to be described has this ability.



The measurement of time always implies a reference, and the practical problem of jitter measurement leads to definitions of three types of time jitter which correspond to three different sources of a time reference. The three types are:

1. *Pulse-width jitter* — the leading edge of the pulse is the reference for measurement of jitter of the trailing edge of the pulse. Both pulse edges are obtained from the pulse source under test by a single coaxial cable connection.
2. *Relative jitter* — the leading edge of a pulse from a second source is the reference for measurement of jitter of the leading edge of the pulse from the first source, such as the leading edges of a generated pulse and its trigger. Thus, two connections to the two pulse sources must be made.
3. *PRF jitter* — the time jitter of the leading edges of the pulses in a train relative to the leading edges of pulses in a second train having the same frequency and average phase, but highly stable for intervals of approximately one second. In the instrument described, the second pulse train is obtained from an internal stable oscillator which is phase locked to the first pulse train by a control circuit with a one-second time constant. In this case there is but one connection to the external pulse source being checked.

To be thoroughly useful and practical, an instrument to measure the time jitter of pulse edges (commonly called a pulse-jitter tester) must perform the following functions:

1. Linearly convert time variations to voltage variations.
2. Provide meter reading of peak jitter level.
3. Provide output for scope display of disturbance waveform.
4. Measure all three types of time jitter over a wide range of time-jitter amplitude.
5. Accommodate a wide range of pulse-repetition frequencies and input-pulse widths.
6. Accommodate both small and large time spacings between the reference pulse edge and the pulse edge under measurement.
7. Provide broadband amplification of pulses prior to conversion of time-variation information to voltage-variation information, in order to avoid attenuation of time-jitter information by filter action.
8. Maintain high signal-to-noise ratio by minimizing residual hum and noise pickup in the instrument.

The LFE Model 5015 Time Stability Tester meets all of the above requirements in an easy-to-use instrument with stable characteristics. Accommodating pulse-repetition rates from 50 to 50,000 pps, it measures time jitters up to one microsecond peak with residual jitter (the equivalent of internal noise) below .0005 microseconds. Meter ranges are 3, 10, 30, 100, 300, and 1000 millimicroseconds peak. The time spacing between the reference pulse edge and the pulse edge under measurement can range from zero to thousands of microseconds, the upper limit depending on the pulse repetition frequency.

Amplitude jitter in a pulse train is detectable by varying the voltage level on the pulse at which the time jitter measurement is made. An important feature of the Model 5015 is that a front panel control is provided for this purpose. The instrument is also capable of measuring anode delay time, and slow changes thereof, a special application in the testing of hydrogen thyratrons.

Another unusual capability of this instrument is its ability to measure PRF jitter of a sine-wave as well as pulse-train input, provided that the slope of the sine-wave at the zero crossing is equal to or greater than approximately .06 volts/microsecond. Hence instability of a PRF pulse train can be traced back to its sine-wave source, if it has such a source.

Since a jitter measurement of a sine-wave input is possible, the relation between peak frequency deviation and peak time deviation may also be of interest. In the case where the time modulation of the input signal is sinusoidal and the input signal frequency is at least ten times the modulation frequency, the relationship is:

$$f_p = 2\pi f_d \, f_r \, \triangle t$$

where f_p = peak deviation frequency,
f_d = disturbance or modulation frequency,
f_r = PRF or sine-wave input, frequency, and
$\triangle t$ = peak time jitter or deviation.

Although the principal specifications of the Model 5015 are covered above, an interested reader can obtain more detailed information including mechanical and other data by requesting Bulletin 5015. For this bulletin, or the answers to particular questions, write Mr. Perry Pollins at the address below.

LABORATORY FOR ELECTRONICS, INC.
714 Beacon Street, Boston

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▸ CLOSING DATE FOR ORDERS

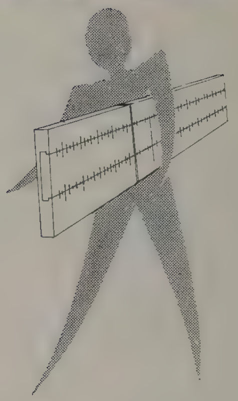
AUGUST 1st

▸ CLOSING DATE FOR PLATES

AUGUST 8th

the microwave engineers' handbook
and buyers' guide

1330 BEACON ST., BROOKLINE 46, MASS. REgent 4-3220



Wesgo
Skilled specialists in premium ceramics for electronics!

WESGO delivers all the advantages of premium alumina ceramics

with the plus quality you need for vacuum tube envelopes and internal spacers, rf windows, heat sinks, high-voltage insulators, semiconductor components and a wide array of precision electronic applications.

Wesgo's specialization in ceramics for electronics gives you unique reliability in components you can depend on.

Three dense, vacuum-tight Wesgo alumina bodies, with up to 99.5% Al_2O_3, are strong, hard and abrasion resistant. They offer exceptional chemical inertness, high thermal conductivity and superior electrical properties, even at extremely high temperatures.

All Wesgo high alumina ceramics feature very low loss factor, high dielectric strength and high resistivity. All are available in sizes and shapes to meet your individual specifications. Manufacturing is to tight dimensional tolerances; ceramics are of uniform density, free from internal and surface defects. All are quality-controlled to meet unparalleled performance standards, with extraordinary care taken in each step of the manufacturing process.

Also available from Wesgo, a complete line of low vapor pressure, high purity, precious metal brazing alloys. Write today for information.

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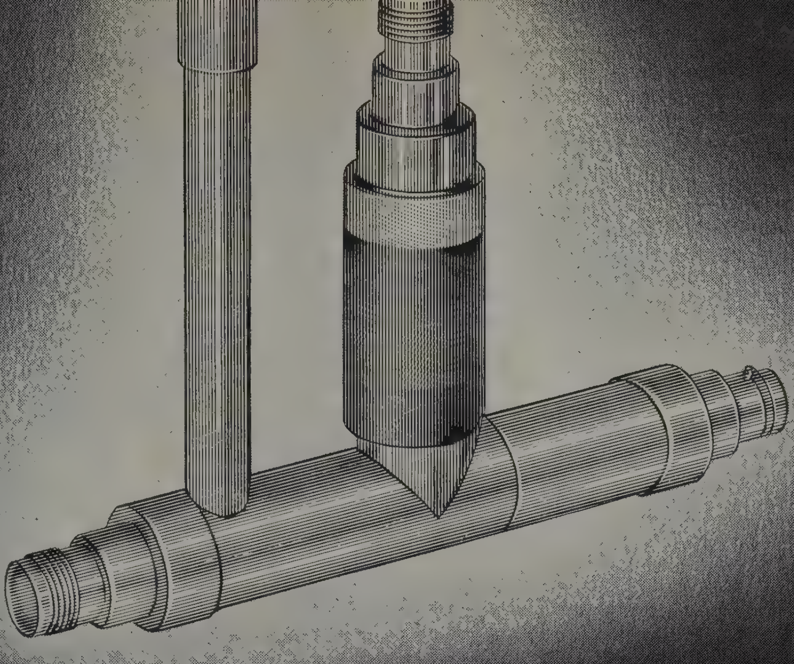

NEW

CRYSTAL MIXERS

FOR USE AS LABORATORY INSTRUMENTS OR IN AIRBORNE SYSTEMS.

A COMPLETE LINE OF CRYSTAL MIXERS IS NOW AVAILABLE FOR IMMEDIATE DELIVERY. THE XR SERIES, FIXED TUNED UNITS, ARE AVAILABLE IN STANDARD FREQUENCIES FROM 225 TO 6000 MC. THE XS SERIES ARE UNTUNED UNITS EACH COVERING THE ENTIRE FREQUENCY RANGE FROM 10 TO 6000 MC. THE XT SERIES ARE TUNABLE UNITS, ONE COVERS FREQUENCIES FROM 300 TO 2000 MC, THE OTHER COVERS FREQUENCIES FROM 1000 TO 6000 MC. FEATURING HIGH CONVERSION EFFICIENCY AND LOW NOISE OUTPUT, THESE CRYSTAL MIXERS ARE MINIATURIZED, RUGGED AND LIGHTWEIGHT. WRITE FOR CATALOG 10A.

MICROLAB

West Mt. Pleasant Avenue • Livingston, New Jersey • WYman 2-570

Industry News

(*Continued from page 56*)

LENG APPOINTED TO THREE POSITIONS AT QUANTATRON

Richard B. Leng has been elected executive vice president, chairman of the executive committee, and a director of Quantatron, Inc., Santa Monica, Cal., it was announced by Robert M. Salter, Jr., president of the firm.

Mr. Leng was previously group vice president, Industrial and Defense Products, and a member of the board of directors of Packard Bell Electronics.

Mr. Leng has spent 25 years in engineering, manufacturing, and management positions in the electronics and aerospace industries. He has been active as a member of the executive committee, Military Products Division of the Electronic Industries Association and is also a member of the National Executive Reserve, Electronics Division, U.S. Department of Commerce.

— *mwj* —

ELECTRONICS FIRM ESTABLISHED

The establishment of a new electronics firm to be known as Electromagnetic Technology Corporation has been announced. EMTECH has commenced operation as a research, development and engineering organization with headquarters in the Stanford Industrial Park, Palo Alto, Cal.

EMTECH was founded by a group of prominent San Francisco Peninsula electronic scientists and engineers including Dr. Alden H. Ryan, Dr. William A. Edson, Fred W. Morris, Jr. and Edward K. Proctor, Jr. in association with Edward O. Boshell of New York. The founders constitute the Board of Directors and officers of the company.

EMTECH will be headed by Dr. Alden H. Ryan as President. Dr. Ryan was formerly the manager of the General Electric Microwave Laboratory at Stanford and previously an associate superintendent of the Naval Research Laboratory.

Dr. William A. Edson, one of the nation's outstanding authorities on microwave technology and circuit theory, will serve as Vice President and Director of Research.

EMTECH will operate as a research, development, engineering and production company in the broad field of electromagnetic technology with initial emphasis on research and development programs for industrial and governmental clients.

— *mwj* —

GILDEN JOINS MICROWAVE ASSOCIATES STAFF

Microwave Associates, Inc., Burlington, Mass., announces the appointment of Dr. Meyer Gilden as senior engineer in the Electron Tube and Device Division. Dr. Gilden will be engaged in plasma physics research and will report to Dr. Lawrence Gould, vice president in charge of the Electron Tube and Device Division.

Prior to joining Microwave Associates, Dr. Gilden was a research engineer in the Electromagnetics Laboratory at Stanford Research Institute in Menlo Park, Cal., where his principal activity was with parametric amplifiers.

He received his Bachelor's degree (1946) and Master's degree (1948) in Electrical Engineering from the Illinois Institute of Technology and his doctorate in electrical engineering from the University of Illinois in 1955.

He is a member of the Institute of Radio Engineers, American Physical Society, Sigma Xi, and Eta Kappa Nu.

— *mwj* —

(*Continued on page 64*)

ALL SIZES
M S FLANGES
IN STOCK

THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVEGUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

SEND FOR NEW BROCHURE #14B DESCRIBING AND ILLUSTRATING ALL THE STOCK FLANGES

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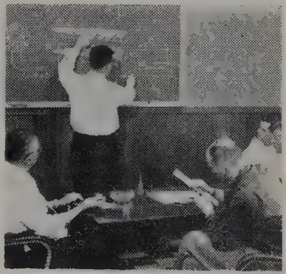

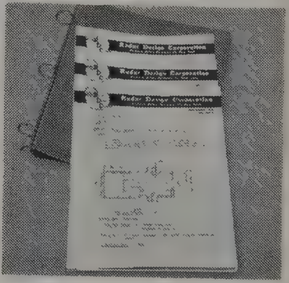

MICROWAVE COMPONENTS DESIGN HANDBOOK

THE DESIGN METHOD SERIES

(Issued in monthly installments) was created primarily for use by our design personnel — and is now available to yearly subscription*

EACH ISSUE COVERS A SPECIFIC COMPONENT AND GIVES:

- "State-of-the-Art"
- A detailed procedure for adjusting a given set of specs to "realism"
- Detailed practical design procedure
- A detailed case history to illustrate the method and develop a "feel for quantity"

* **$35.00 per year — all back issues are available.**

Write for detailed descriptive information.

Just another unusual service from one of the WORLD'S MOST VERSATILE MICROWAVE COMPONENTS DESIGNERS

RADAR DESIGN CORPORATION
Pickard Drive — Box 38
Syracuse 11, New York
GLenview 4-4418
TWX SS-437-U

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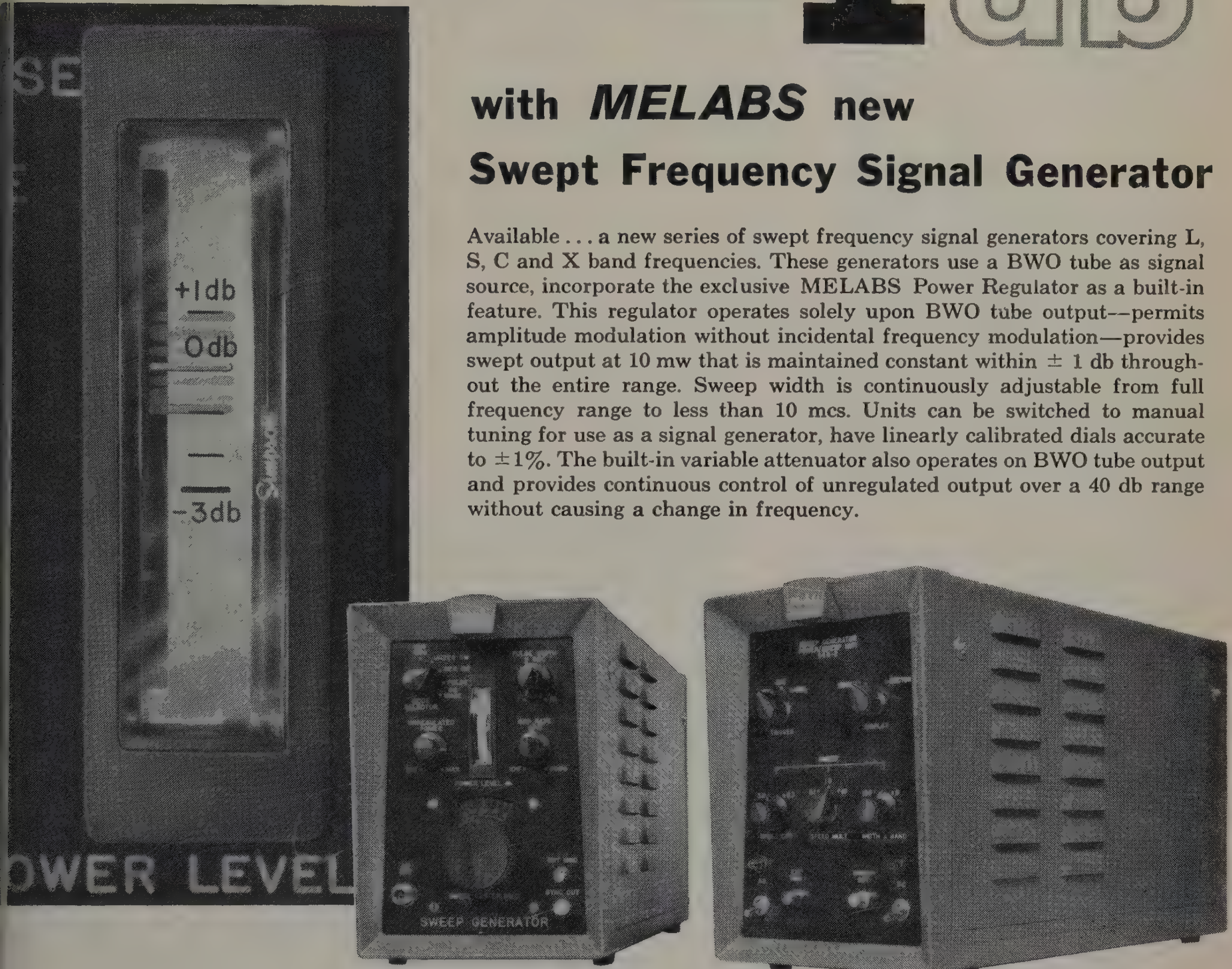
...OUTPUT CONSTANT ±1 db

with *MELABS* new Swept Frequency Signal Generator

Available . . . a new series of swept frequency signal generators covering L, S, C and X band frequencies. These generators use a BWO tube as signal source, incorporate the exclusive MELABS Power Regulator as a built-in feature. This regulator operates solely upon BWO tube output—permits amplitude modulation without incidental frequency modulation—provides swept output at 10 mw that is maintained constant within ± 1 db throughout the entire range. Sweep width is continuously adjustable from full frequency range to less than 10 mcs. Units can be switched to manual tuning for use as a signal generator, have linearly calibrated dials accurate to ±1%. The built-in variable attenuator also operates on BWO tube output and provides continuous control of unregulated output over a 40 db range without causing a change in frequency.



The generator "package" is broken down into two units to reduce weight, facilitate easy carrying by one man. The same power supply/sweep unit can be used with any of the MELABS electronically tuned generators.

The many built-in features of these generators tend to reduce materially the amount of external equipment necessary for accurate visual presentation of equipment characteristics. Operation is simple, straightforward.

SPECIFICATIONS (Similar for all units)

POWER OUTPUT: Regulated, 10 mw ±1 db. Unregulated, continuously adjustable over 40 db range.

INTERNAL MODULATION: For regulated power: **Pulse,** 1-10 usec. width, prf, 100-5000 cps. **Square wave,** repetition rate 1000 cps with ±10% front panel adjustment.

EXTERNAL MODULATION: Any type, unregulated only.

SWEEP: .03 to 30 cps with sweep widths continuously adjustable to 100% of Frequency Range.

DIMENSIONS: 11"H, 8"W, 21¼"D, each unit.

WEIGHT: Power supply, approx. 65 lbs. **RF heads,** approx. 35 lbs.

AVAILABLE MODELS: RF heads,
Model **SGL-2,** 1-2 kmc.....2600.00
Model **SGS-2,** 2-4 kmc.....2300.00
Model **SGC-2,** 4-8 kmc.....2400.00
Model **SGX-2,** 8-12 kmc....2600.00

POWER SUPPLY/SWEEP UNIT (required for each RF head)
Model **SGO-2**............900.00
will operate with any of the listed RF heads.

DATA AND PRICES SUBJECT TO CHANGE WITHOUT NOTICE. PRICES F.O.B. FACTORY.

Employment opportunities at Melabs are exceptional for ambitious engineers and physicists; write in confidence.

We will be at the WESCON Show in San Francisco, Booth 1122.

Melabs
3300 Hillview Avenue, Palo Alto, California Dept. A-3 DA 6-9500 Area Code 415

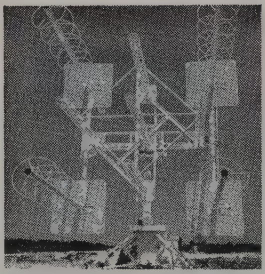
Spring may be when a young man's fancy. To us, it means the company picnic: that gay, sun-filled time of lost children, not enough beer, flies, broken arms and problems caused by attached and unattached females. We, at Rantec, have noticed that the electronic engineer is one of the most democratic of characters. In the area of the company picnic, however, he becomes a monster subject completely to minority rule. Every year about this time we begin to hear the rumbles . . . *"Let's not have another one of those picnic things."* Pretty soon it becomes quite obvious that no picnic will be held this year, until the assistant multilith operator's secretary says, *"How about a picnic?"* . . . and there you have it.

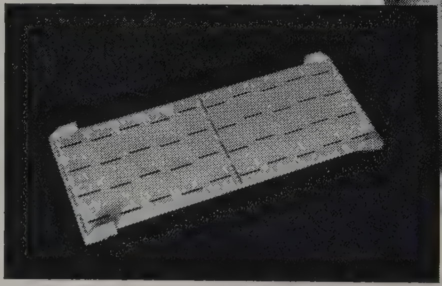
One of the major problems of the annual outing is always, as we have mentioned before, not enough beer. It is very mysterious. In 1957, we had one barrel for forty people. *Not enough.* In 1958, we had three barrels for sixty people. *Not enough.* Last year, we had ten barrels for eighty people. *Still not enough. (This, we hasten to explain, was seemingly not due to heavier drinking or any increase in the level of intoxication.)* One of our more erudite scientists applied his slip stick to the problem and came up with no explanation whatsoever. An analytical psychologist friend of ours suggested that harder, more advanced work plus the increase in relative frustrations and *"on-the-job"* neuroses over the years might supply an answer. This, however, is absurd. The atmosphere of work at Rantec is one of sublime quietude in which, at his leisure, each engineer is left alone to think and accomplish without being bothered by everyday problems such as, *"How come this only gives me 15 db at band center when your advertising says 18?"* What we do, naturally, is blame the whole thing on our advertising man and let the engineer get back to work.

We thought we'd solve the whole problem by taking everybody up to Las Vegas for a weekend, but cast that idea aside rather quickly. There's absolutely too much beer up there and besides how would you like to lose one of your children and/or wives in Las Vegas. Engineers with experience in antenna development, microwave theory and, especially, picnicking can write, call or wire the Rantec Corporation, Calabasas, California. This year we're having twenty barrels.

* * *

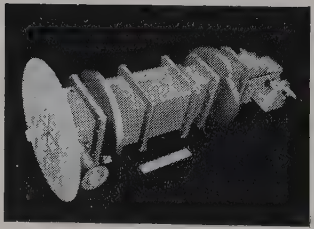
HELICAL





2D SLOT ARRAY

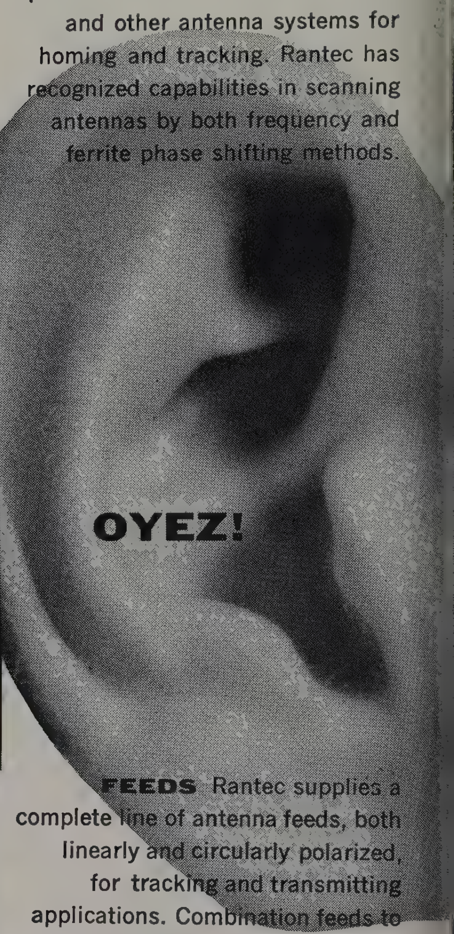
FEED



"Hearing" is one of Rantec's best known specialties. In countermeasures, command, communication or telemetry, Rantec is an important supplier to missile and space exploration programs.

HELICAL Through its development of hybrid and other r-f circuitry, Rantec provides the essential elements of many self-tracking telemetry systems. (Illustrated is Rantec's "outboard-inboard" array at Cape Canaveral.)

2D SLOT ARRAYS Rantec produces conical scan, monopulse and other antenna systems for homing and tracking. Rantec has recognized capabilities in scanning antennas by both frequency and ferrite phase shifting methods.



FEEDS Rantec supplies a complete line of antenna feeds, both linearly and circularly polarized, for tracking and transmitting applications. Combination feeds to provide multiple frequency coverage are available for various bands. Field teams are provided for "on-site" installation of waveguide runs and feed assemblies.

Also from rantec . . . ferrite devices, wave guide components, r-f telemetry components, electronic components and microwave sub-systems.

rantec

rantec corporation calabasas, california

Circle Reader Service Card 45

PROGRESS IN MICROWAVES

New General Electric VTM's and TWT's . . .

ADVANCE S- AND X-BAND TRANSMITTER CAPABILITIES

Provide Higher Power in Lighter, Smaller Tubes

Four new General Electric power tubes—two voltage-tunable magnetrons and two traveling-wave tubes—have been designed to advance transmitter capabilities in S- and X-bands. All provide higher power in smaller, lighter, more compact packages for missile and airborne transmitter applications.

HIGH EFFICIENCY, LIGHT WEIGHT VTM's

Designed primarily for space applications, the Z-5428 voltage-tunable magnetron achieves an efficiency of 35 percent in a tube weighing only 4.5 pounds. Moreover, it operates under severe shock and vibration conditions with only radiation cooling. Tests show the Z-5428 meets shock requirements of 40 G's for 11 milliseconds and vibration requirements of 5 to 25 cps at one quarter-inch double amplitude; and from 25 to 2000 cycles at 10 G's.

Equally efficient and compact, the Z-5424 provides high power (50 W min.) in an exceptionally light (4.5 pounds) VTM. And like the Z-5428, it is a complete r-f power package requiring only input and r-f output power connections.

Both VTM's can be linearally voltage-tuned without mechanical adjustment.

HIGH-POWER, COMPACT TWT's

The two new high-power traveling-wave tubes are designed to operate in series, one as the driver and one as the final amplifier in a pulsed high-power chain for X-band radar applications. They are compact, of metal-ceramic construction, and incorporate an advanced focusing system utilizing periodic permanent magnets requiring no temperature stabilization. The Z-3090 driver tube weighs only 15 pounds while the Z-3091 amplifier tube weighs 42 pounds with electrical connectors. Both tubes are ruggedized for airborne applications and can be mounted in any position.

These TWT's, as well as the new VTM's, are now available in sample quantities. Delivery in 90 to 120 days.

265-06

FREQUENCY RANGES AVAILABLE*

VTM's OSCILLATOR SERVICE

Frequency (KMC)	P_0 (Min. CW)
2.2 – 2.3	10 W
2.5 – 3.5	10 W
2.9 – 3.2	50 W
5.17 – 5.42	10 W

TWT's AMPLIFIER SERVICE

Frequency (KMC)	P_0 (Min. Peak)
5.4 – 5.9	25 KW
8.5 – 9.6	5 KW
8.5 – 9.6	50 KW
8.5 – 9.6	250 KW

These tubes can be scaled to meet specific frequency and power requirements.

TO ORDER, or obtain more information, contact your nearest Power Tube Sales office (telephone numbers listed below).

POWER TUBE DEPARTMENT

GENERAL ELECTRIC

TELEPHONE TODAY—Syracuse, OL 2-5102 . . . New York City, WI 7-4065 . . . Clifton, N. J., GR 3-6387 . . . Washington, D. C., EX 3-3600 . . . Chicago, SP 7-1600 . . . Dayton, BA 3-7151 . . . Orlando, Fla., GA 4-6280 . . . Los Angeles, GR 9-7765

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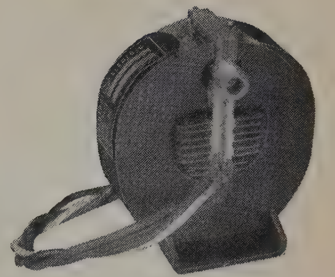
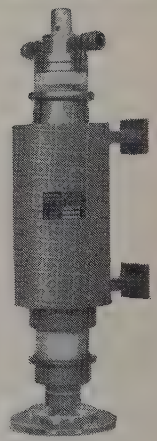


Z-5424: 50 percent efficiency—2900 to 3200 mc.

Z-5428: Designed for space—2200 to 2300 mc.



Z-3091: Periodic permanent-magnet focus high-power traveling-wave tube

LOOK TO G-E POWER TUBE DEPARTMENT FOR:

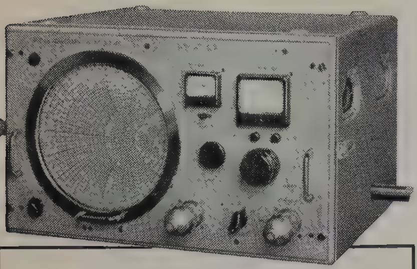
- Ignitrons
- Hydrogen Thyratrons
- Magnetrons
- Metal-ceramic Tetrodes
- High-power Duplexers
- Klystrons
- Thermionic Converters
- Traveling-wave Tubes
- Harmonic Filters

ROHDE & SCHWARZ

DIAGRAPHS

PLOT IMPEDANCE DATA
ON ANTENNAS, FILTERS,
SEMI-CONDUCTORS . . .

INSTANTLY, ACCURATELY
AND ECONOMICALLY

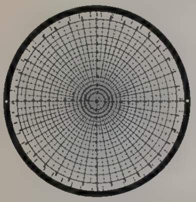


Range: 30 to 2400 MC

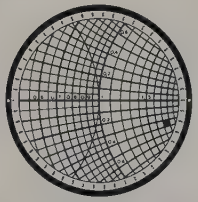
The Diagraphs employ the directional coupler principle. Measurements are read directly on Smith or transmission-line chart without computation, saving time, expense, and eliminating error. Baluns, variable shorts and accessories for measurements of semi-conductors available.

4 MEASURING USES:

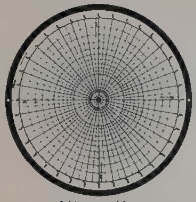
- **Impedance and Admittance Measurements**
- **Plotting Transmission Characteristics**
- **As a Phasemeter from –180° to +180°**
- **As a Linear Measuring Receiver**



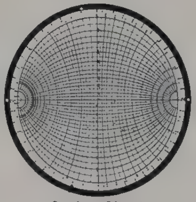
Reflection Coefficient



Expanded Smith Chart



Attenuation
and Phase Angle



Carter Chart
(Polar Coordinates)

Frequency Range	Type	Ω
30 to 420 mc	ZDU	50*, 60 and 75
300 to 2400 mc	ZDU	50* and 60

*NORMALLY STOCKED

Write for data sheets and demonstration

**ROHDE &
SCHWARZ**

111 Lexington Ave., Passaic, N. J.
PRescott 3-8010

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Industry News

(*Continued from page 60*)

DR. LAWRENCE JONES NAMED LORAL STAFF SCIENTIST

Loral Electronics Corp., New York, N. Y., announces the appointment of Dr. Lawrence F. Jones of Baltimore as staff scientist.

Dr. Jones was formerly chief of the digital branch of the Norden Division of United Aircraft Corp. and prior to that, advisory engineer in charge of the digital computer group at the Air Arm Division of Westinghouse Electric Corp.

The holder of an S.B. degree in chemical engineering and a Ph.D. degree in mathematics from M.I.T., Dr. Jones is a member of the Professional Group on Electronic Computers, Institute of Radio Engineers, and chairman of its bibliography committee. He is also a visiting lecturer on research administration at the University of Pennsylvania.

—*mwj*—

AIL APPOINTS MANAGER OF NEW WASHINGTON OFFICE

Richard G. Weber has been appointed regional planning manager and will form and manage the Washington office of Cutler-Hammer's AIL division, Dr. Hector R. Skifter, president of AIL (Airborne Instruments Laboratory), Deer Park, L.I., has announced.

Weber will be responsible for representing Cutler-Hammer's AIL division in the Washington, D.C. area.

Before joining AIL, Mr. Weber was the manager, systems planning, of General Electric Co., Bethesda, Md.

A graduate of the U.S. Military Academy at West Point in 1948, he received his master of science degree from the University of Michigan in 1954.

—*mwj*—

COLLINS AWARDED NAVY CONTRACT

Collins Radio Company, Cedar Rapids, Iowa, has been awarded a $160,000 contract to supply the U. S. Navy with additional airborne ultra high frequency communication equipment.

Equipment called for in the Navy contract are Collins ARC-52 communication transceivers which are used aboard a wide range of Navy aircraft and provide communication on 1750 crystal controlled radio channels in a frequency range of 225 Mc - 399.9 Mc.

—*mwj*—

WESCON TOURS DISCLOSED

A sampling of research and production activities in the San Francisco Bay Area will be featured in the field trips program of WESCON August 22-25.

The field trips committee has announced its choices of facilities to be visited, all closely linked to major sections of the technical program at the Cow Palace during the run of the convention.

Bus service from the Cow Palace will be offered for the following scheduled tours:

Tuesday afternoon, August 22 — Litton Industries' Electron Tube Division at San Carlos, to inspect high-power and superpower tube facilities; the University of California's Lawrence Radiation Laboratory at Livermore, where emphasis will be placed on basic work in plasma research (this tour limited to 50).

Wednesday afternoon, August 23 — Stanford University Microwave Laboratory will provide an opportunity to learn about research in two fields; that is (1) ionized cesium plasma and (2) electron guns and ion propulsion engines. Another tour visits the joint Radio Field Site of Stanford University and Stanford Research Institute, with its wide variety of experimental installations used for radio-astronomy projects.

Thursday morning, August 24 — MELABS, in Stanford Industrial Park at Palo Alto, for a general tour of new facilities devoted to research, development and production of microwave devices (including cavity masers, S-band traveling-wave masers and L-band parametric amplifiers).

Thursday afternoon, August 24 — Hewlett-Packard Co. and its newly expanded center in Stanford Industrial Park, with attention to be concentrated on production areas (prefabrication, wiring and assembly, test and calibration, quality assurance).

—*mwj*—

ANTENNA PEDESTAL FOR SPACE TRACKING BEING BUILT

A new high performance, general purpose radar antenna pedestal, to be used initially for the tracking and control of space vehicles, is being built in Alexandria, Va. by the Aero Geo Astro Corp., it has been announced by Thomas B. Mechling, executive vice president.

The pedestal will handle radar antennas up to approximately 36 feet in diameter. A rugged piece of equipment, the pedestal resists high winds, icing and salt corrosion. It is constructed of aluminum for lightness, and has pressure lubricated gear boxes for long wear. It gives full elevation and azimuth coverage and is built to be mounted on a 25-foot tripod tower. Weight is limited to three tons to permit air transportation.

—*mwj*—

SYLVANIA NAMES LOVENSTEIN ANAGER OF PROJECT ADVENT

The appointment of Allen J. Lovenstein manager of the ADVENT satellite communications program at the Waltham, Mass., Laboratories of Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., has been announced by Richard M. Osgood, General Manager. The Waltham program is ng conducted under the direction of U. S. Army ADVENT Management ency and the technical guidance of U. S. Army Signal Research and De- opment Laboratory, Fort Monmouth, J.

Project ADVENT embraces work lead- to a determination of the feasibility a world-wide communications network it will operate through utilization of ationary" satellites. Sylvania is respon- le for development, fabrication and tallation of all operations facilities for two ADVENT satellite tracking and minal communications stations being nstructed at Fort Dix, N.J., and Camp berts, Cal.

The company project includes design d fabrication of towers and super struc- es that will aim gigantic 60-foot para- lic reflector antennas at each station th their complex multi-feed systems to ck distant satellites within an accuracy ver before attained.

—mwj—

PPLIED MICROWAVE PURCHASES BALTIMORE FIRM

J. Kelsey Burr, 3rd, president of Ap- ied Microwave Electronics, Inc., has an- unced the acquisition of the Service achine Co. of Baltimore, Md.

Francis X. Gaeng, former president of e Service Machine Co., has been elected the new board of directors and will, addition, be responsible for the creation a new independent sales organization market the manufacturing services of e company. The company will be moved Applied Microwave Electronics' new 50,000 plant in the Meadows Industrial rk section of Baltimore county.

The Service Machine Company will re- in its name and will be operated as an dependent subsidiary of Applied Micro- ave Electronics. Vernon R. Goldberg has en named general manager of Service achine Co.

Mr. Burr stated that the acquisition ll increase production capacity by 50 r cent and offer increased services to stomers for high-power passive micro- ave components, microwave antennas d an increased variety of microwave stems components.

—mwj—

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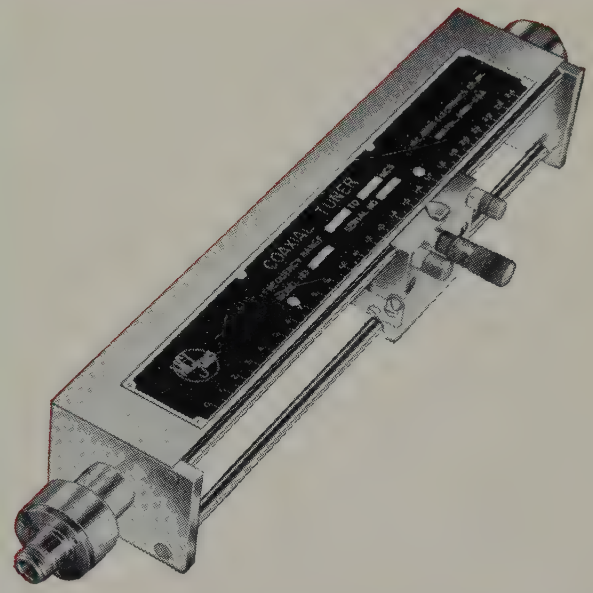

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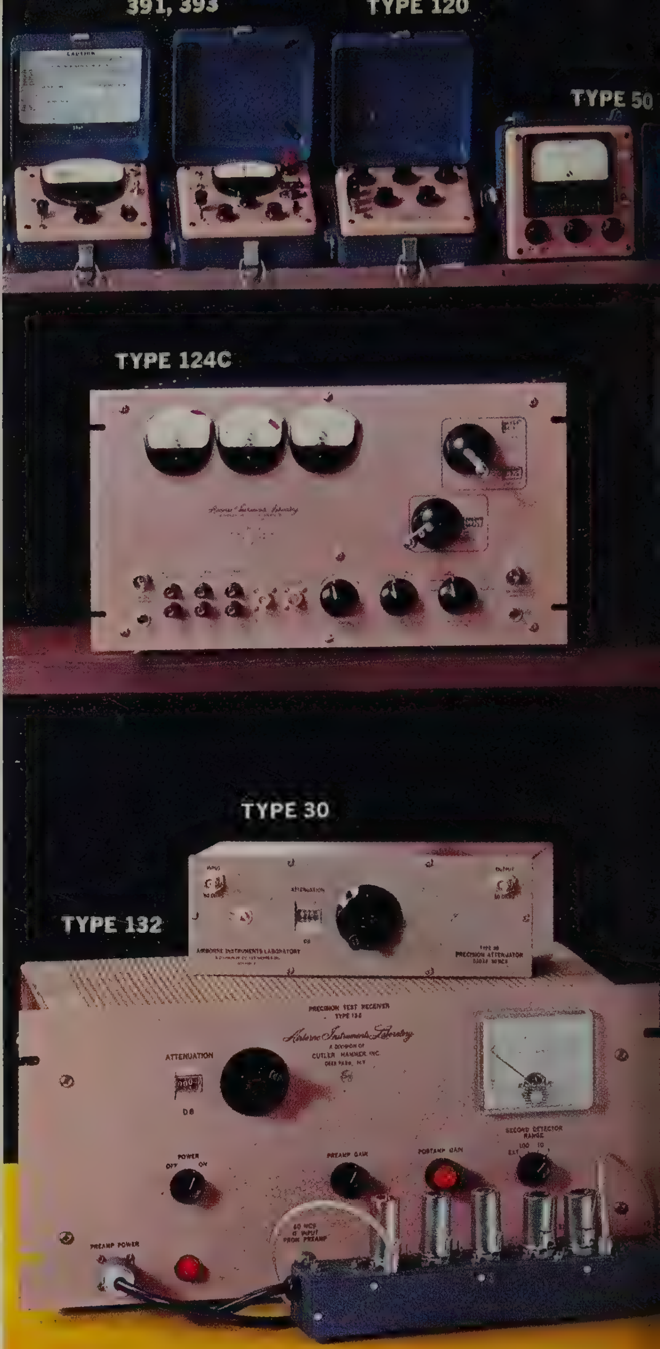

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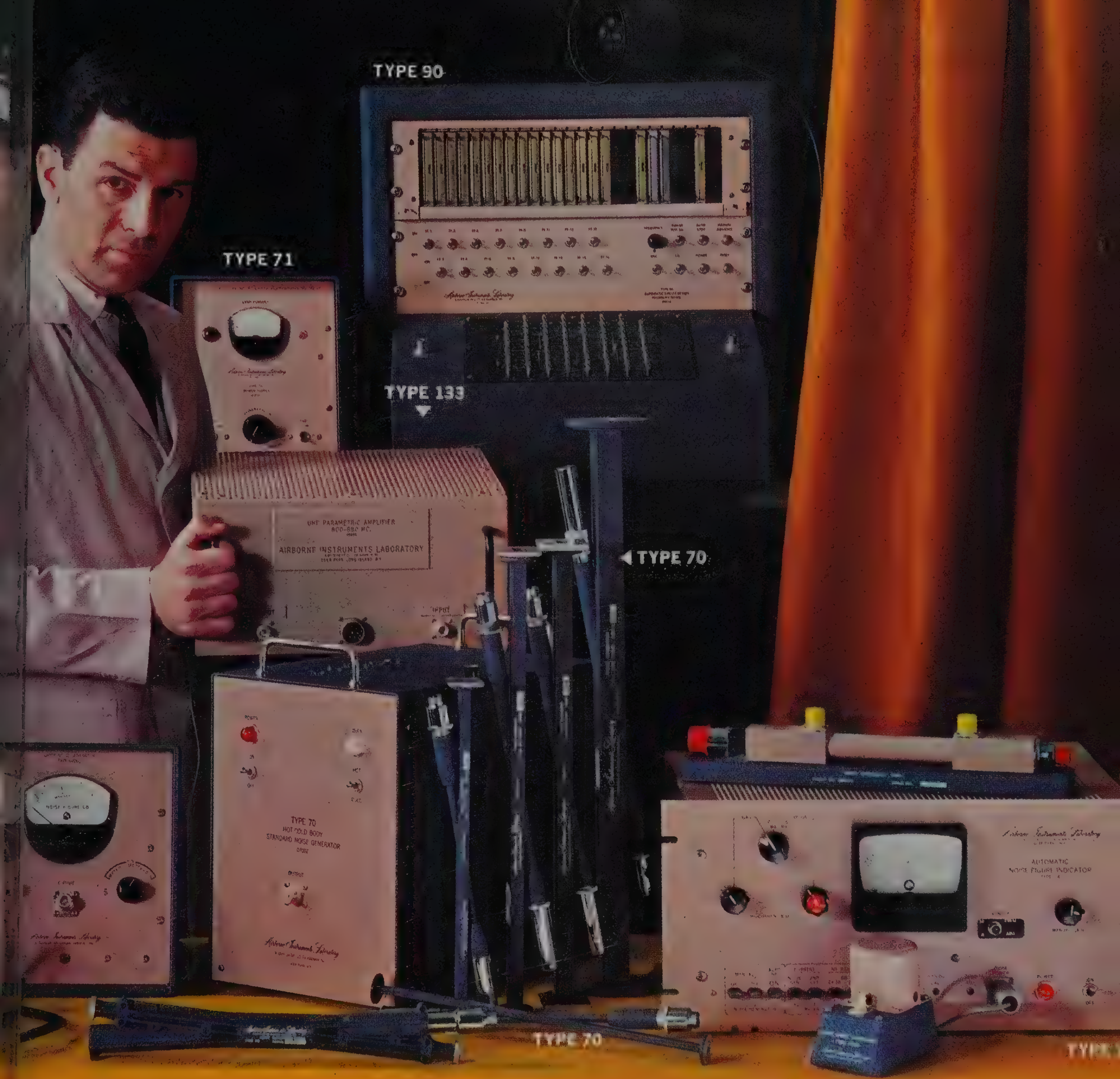

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MICROWAVE DEVICE NEWS from SYLVANIA

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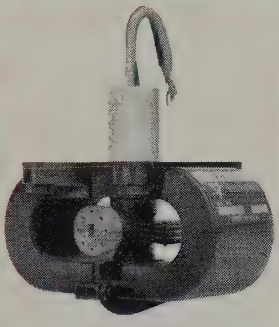

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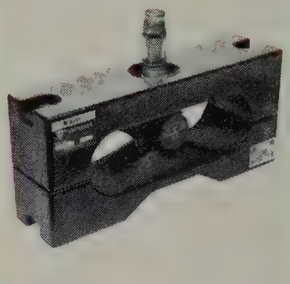

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6799	34.512 35.208	120	.0005	1.0
M-4155A	34.512 35.208	40	.0006	1.0
XM-4064	34.512 35.208	70	.0008	1.0
XM-4158	34.512 35.208	120	.0008	1.0
XM-4218	34.512 35.207	32	.0006	0.4
XM-4206	34.7 35.0	40	.0006	1.1

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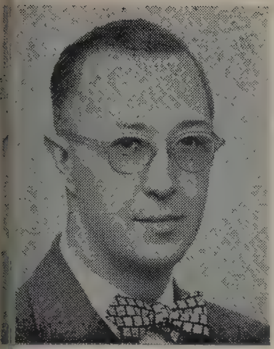
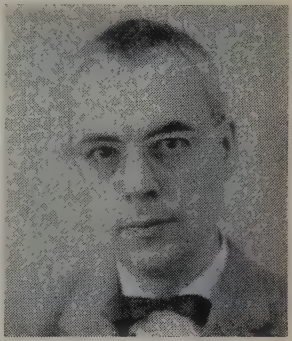


HERBERT C. ALEXANDER was born in Medford, Mass. in 1918 and received a BS degree in electrical engineering from Northeastern University in 1941. From 1941 to 1951 he was employed at Sylvania Electric Products, Inc., Salem, Mass. as a Development Engineer, and from 1944 to 1946 he served in the USNR as a Radar Officer.

Mr. Alexander joined Bomac Laboratories in 1951 as a Project Engineer and presently holds the position of Manager, Microwave Product Development.



THUR G. BARRETT was born in New London, N.H. in 1922 and received a
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od, Mass., as Junior Engineer and from 1950 to 1954 was employed as an Elec-
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At present Mr. Barrett is an Electronic Engineer in the Gas Switching Section
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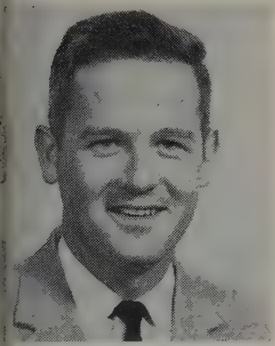

WILLIAM L. SHELTON was born September 18, 1931, Daytona Beach, Fla. and received a BS degree in electrical engineering from San Jose State College in 1958.

He served in the U.S. Navy as an electronics technician during the Korean War and was leading technician aboard the USS Rainier AE-5.

In 1957 he joined Sylvania Electronic Defense Laboratories, and at present he is an engineer engaged in the design and development of microwave components.

Mr. Shelton is a member of the IRE and PGMTT.

CHARLES T. STELZRIED was born on September 14, 1928, in Los Angeles, Cal. After serving in the U.S. Navy for six and one half years as an electronic technician, he entered UCLA. There, he received both his BS and MS degrees in engineering.

Work on parametric amplifiers provided not only an MS thesis topic and an introduction to low-noise amplifiers and associated microwave components, but also served as a background for deep-space communications problems, his present interest at Caltech's Jet Propulsion Laboratory, where he has been employed as technician and research engineer since 1953.

Mr. Stelzried is a member of Tau Beta Pi, AAAS, and the IRE and has several patent disclosures on parametric devices.

ANG P. YEH received his BS degree in electrical engineering from Chiao-Tung
iversity, Shanghai, and his MS degree in communications engineering from Har-
rd University.

During the past 22 years, in this country and in his native China, he has done
th design and installation engineering of automatic telephone exchange, broad-
sting equipment, and telephone and radio communication systems.

He has been Chief Engineer for the Canton Telephone Administration, Purchase
gineer for the Universal Trading Corp., Chief Resident Engineer of the China
ectric Co., Ltd., Assistant Chief Engineer for Radio Hong Kong, Cable and Wire-
s Ltd., faculty member of Colorado A and M College, Fellow Engineer with West-
ghouse Electric Corp., and Consultant for General Electric Co. At present he is
ull time consultant for Page Engineering Co.

Mr. Yeh is a member of the IRE and the British Institution of Electrical En-
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NTRODUCTION

Radio communication systems operating in the microave frequency ranges, e.g., from 400 to 10,000 mc, e becoming increasingly important in the field of teleommunications due to advancements in the art. Such stems are competitive and comparable, in many repects, to wireline, coaxial cable, and submarine cable stems. This article attempts to summarize recent proess from the system and propagation viewpoint by eviewing relevant literature at the present state of the t.

The advantages of microwave radio generally are: 1) high and flexible channel capacity — from a few oice channels to several television channels (which ould provide thousands of voice channels); (2) easy xpansion in capacity (once the initial installation has een completed, additional capacity can be added ready); (3) shorter installation time; (4) better adaptaon to difficult terrains and natural barriers such as ater and mountainous or densely wooded areas — in ese particular applications both initial and maintennce costs are lower when compared to line or cable ystems.

Disadvantages, on the other hand, are: (1) signal ading, (2) difficulties in obtaining suitable terminal tings and regular power supplies, and (3) interfernce at radio frequencies. These disadvantages, hower, are surmountable.

Most of the microwave radio communication systems n use today fall into two main categories, namely, (1) *ine-of-sight systems* — low transmitter power up to 20 vatts for line-of-sight paths ranging from 10 to 50 staute miles in length per link. (Satellite communication, nother form of microwave line-of-sight systems, is a subect by itself and is excluded from the present study); (2) *ver-the-horizon systems* — high transmitter power up o 50 kw or more for beyond-the-horizon paths from 50 o 500 or 600 statute miles in length per link, including oth diffraction and tropospheric-scatter modes of propaation.

LINE-OF-SIGHT SYSTEMS[1-11]

The feasibility of using radio links at vhf and uhf frequencies for telecommunication purposes was proven by experiments prior to World War II. After the war, developments were mainly in the vhf bands. The quality and reliability of these links was found comparable to that of coaxial cables.

As the need for wider bandwidths became more prominent in recent years, uhf and shf frequencies have been used to accommodate the expansion of telephone traffic and the added requirement for television transmission.

Operating Frequencies

The frequency band allocated for point-to-point links by the International Convention at Geneva, in 1959, falls into the following categories: 335-420 mc; 1700-2300 mc; 3400-4200 mc; 5925-8500 mc; and 10,500-13,250 mc. Detailed assignments within each band vary considerably in individual countries.

The frequency choice depends on many factors. Higher frequency provides more antenna directivity, less "first Fresnel zone" clearance (which means that lower antenna towers can be used), broader available bandwidth and, perhaps, more compact equipment. On the other hand, propagation loss, fading, and receiver noise figures increase with frequency. Furthermore, available transmitter power tends to decrease as the frequency increases.

There are other limitations such as: appreciable absorption by rain, fog, and snow around or above 10,000 mc; significant absorption by water vapor and oxygen at about 20,000 mc; and more atmospheric and manmade noises near the lower end of the uhf spectrum. Because of these restrictions, recent development efforts have been concentrated at the 1000 to 10,000 mc frequency range.

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Multiplex and Modulation Techniques

Although both frequency-division multiplex (FDM) and time-division multiplex (TDM) techniques have been utilized, FDM is more extensively used, especially for systems of high-channel capacity (up to 2500 channels). TDM is limited to low-channel capacity systems (48 channels or less) as it requires a considerably greater frequency spectrum than FDM systems of the same capacity.

Signal-sideband modulation (SSB) is being advocated for FDM systems, but frequency modulation (FM) has been used exclusively so far because of the difficulties in fulfilling the linearity requirements in SSB high-channel systems. Both amplitude modulation (AM) and frequency modulation (FM) have been used for TDM systems.

Fading Characteristics

The statistical fading to which microwave line-of-sight transmission is subject is due to variable atmospheric bending and multipath transmission. Fading due to variations in atmospheric bending could be reduced or minimized by mounting the antenna at suitable heights. Fading due to multipath transmission exhibits various types of statistical distributions (the extreme condition approaches the Rayleigh distribution), depending on the frequency and the path length. System margins must be allowed for fading. A 30-db fading margin from the median is generally required to achieve 99.99% reliability.

A common method of improving reliability and performance or reducing the fading margin is the use of frequency or space diversity. The former requires extra spectrum space while the latter requires extra antennas. Using a single antenna[4] for both transmitting and receiving at different frequencies has also been reported; this scheme saves some of the initial cost. Because of the many links required for long-haul systems, non-demodulating repeaters generally are used to avoid an increase in distortion and noise.

Other Developments

As the bandwidth expected to be carried by radio links is becoming wider and wider [such as 7-8 mc required for transmitting NTSE (National Television Systems Committee) color television signals (Standards for the United States) or 10 mc required for 2500 telephone channels], the natural result is a demand for tubes with more power, wider bandwidth, and lower noise figure in order to maintain the standard reliability and performance. This demand has been met by development of the traveling-wave tube. Today, an increasing number of traveling-wave tubes[5] are used as output devices and an all-traveling-wave tube system[6] has been proposed.

Use of low noise devices such as parametric or maser amplifiers to improve system performance has not been reported, possibly because a gain of several db in noise figure is not enough to offset the cost, equipment complexity, and bandwidth/stability problems of these devices.

Summary

Table I shows the major high-channel capacity, line-of-sight systems used in three countries. The trend seems toward the higher channel capacity. A carrier frequency of 4000 mc is the most popular choice.

TABLE I — High Channel Line-of-Sight Systems[7,8,9,10,11]

Country	USA[7,8,9]			CANADA[10]	ENGLAND[11]	
System	Bell System			Bell System	Post Office	
Type	TD-2	TH	TJ	TD-2	Telephone	TV
Frequency (mc)	4000	6000	11,000	4000	4000	4000
Power (watts)	0.5	5	0.5	0.5	1	10
Modulation	FM	FM	FM	FM	FM	FM
Output Tube	Planar Triode	TWT	Klystron	Planar Triode	TWT	TWT
Radio Channels	5	6	3	5	1	1
Spare Channels	1	2	3	1	1	1
Total Channels	6	8	6	6	2*	2*
Voice Channels per radio channel	600	2500	600	600	240	960
TV Channels per radio channel	1	1	1	1	—	1
Baseband bandwidth (mc) per radio channel	4	10	4	4	1	4
No. Repeaters	125+	125+	6-10	137	—	—
Distance per link (miles)	30-50	30-50	15-30	30-50	30-50	30-50
Range (miles)	4000	4000	100-300	4000	1600	1600

* *Two radio channels operate in parallel at different carrier frequencies.*

TABLE II — Diffraction Loss Relative to Free Space Transmission*

(Smooth earth; standard atmosphere; horizontal polarization over land; one antenna at 500 ft. and the other antenna at 30 ft. above the surface)

Distance (miles)	50	50	50	70	70	70
Frequency (mc)	400	2000	4000	400	2000	4000
Additional loss (db) over free space	31	34	36	50	65	79

* *From Figure 6 of reference 12, "K. Bullington, 'Radio Propagation Fundamentals,' Bell System Technical Journal, pp. 593-626; May, 1957."*

Theoretically a line-of-sight system can be extended over favorable terrain without natural barriers for rather long distances, for example 3000-4000 miles, with many links. The distance to be covered by each link, however, is limited to short distances in the range of 30-50 miles because of economical considerations. For longer links, diffraction or the tropospheric-scatter mode of propagation over the horizon is used.

OVER THE HORIZON[12-48]

Diffraction Mode

That radio energy can be transmitted over the horizon wthin the troposphere by diffraction has long been known. There is however an additional path loss, due to the earth's shadow.

The diffraction loss due to the earth's shadow becomes greater as either the distance or the frequency is increased, and, it will also be affected to some extent by the antenna heights and the terrain. In the theoretical evaluation of the diffraction loss, the earth is usually considered smooth and spherical. Table II, which shows some typical theoretical diffraction losses over a smooth spherical earth as given by Bullington[12], illustrates that a great deal more loss occurs than in line-of-sight transmission. Because the loss increases very rapidly with distance, the diffraction mode of propagation is not used for extended-range communications.

Tropospheric-Scattering Mode

For longer distances per link another over-the-horizon transmission technique called "tropospheric-scattering" must be used. In the frequency range of 100-4000 mc or higher, radio propagation has long been known to extend over paths well beyond the horizon for hundreds of miles. The received signal level is persistently much higher than that predicted by the diffraction theory, even in the absence of anomalies such as ducting or trapping. Thus another propagation mechanism must be involved.

In spite of the extent of practical data now available, technical opinion is still sharply divided[13,14] as to the causes of this type of tropospheric propagation. Many theories have been advanced attempting to explain this phenomenon. Most of them can be grouped under two main categories: (1) scattering due to atmospheric turbulence and (2) partial reflections from horizontal layers. A third[14,15] is based on an alternate form of diffraction theory in which the problem of radio diffraction by the earth is treated as that of refraction in an atmosphere with a linear profile of modified index. Each theory has advantages and disadvantages.[14] The discussions which follow are based mostly on experimental findings.

Extensive experiments during the past few years have established the essential characteristics of the tropospheric-scatter mode of propagation, although certain doubtful areas still exist such as the aperture medium coupling loss, medium bandwidth, etc. Propagation characteristics are briefly summarized below:

(1) *Scatter Loss.* This is the additional loss over the free space loss in line-of-sight transmission. It is statistical in nature and subject to two types of time variations or fadings.

  (a) *Fast fading.* Fast fading, which is believed to be due to multipath effects (phase incoherence of various scatter signals), is a short-term variation of the instantaneous values. It has a Rayleigh distribution, for a sampling time of a few minutes (from 1 to 5 minutes).

  (b) *Slow fading.* Superimposed on fast fading is a slow fading, which is believed to result from the change of the refractive index of the atmosphere. Slow fading is a long-term variation of the median values. Medians taken every hour were used earlier, but recent experiments tend to take 15-30 minute medians. Five-minute[16] and one-minute[17] medians have also been investigated. The medians have diurnal and seasonal effects and are also related to meteorological and climatological conditions.

    (i) The slow fading has a Gaussian distribution over a long period of sampling time, at least for a month and usually for a full year, with a standard deviation of from 2-10 db, depending on the scattering angle.

    (ii) The long term median value (yearly median of all 1-minute, 5-minute, 15-minute, 30-minute, or hourly medians of the whole year) of the scatter loss is of utmost importance because it is used as a basis for system design. It is both distance-dependent and frequency-dependent.

    (iii) Based on experimental data,[18] the yearly median scatter loss for temperate climates is approximately 57 db at 1°

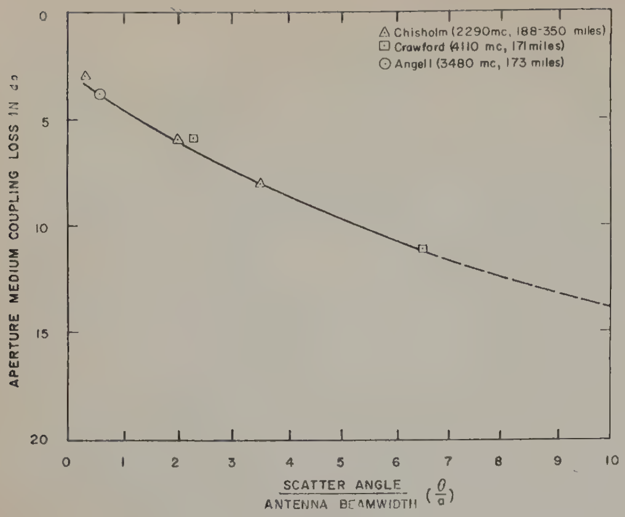

Figure 1 — Aperture medium coupling loss (experimental).

scatter angle (equivalent to a path distance of about 90 miles, smooth earth geometry) and 400-mc frequency. For scatter angle greater than 1°, the increase is about 10 db per degree. For frequencies higher than 400 mc, the increase is about 3 db per octave in the frequency range of 400-4000 mc.

(iv) The median scatter losses are higher in cold dry climates than in warm humid climates, and seasonal variations as much as ± 10 db or more from the yearly median have been observed. Some correlation definitely exists between the mean refractive index and the median scatter loss. A 0.2 db increase in scatter loss per unit decrease in surface refractive index of air is recommended by CCIR.[19]

(v) For distances in the region of about 90 miles or less either the diffraction or tropospheric-scatter mode of transmission is possible. This is, indeed, a very hazy region. The conventional method[20] is to determine both diffraction and scatter losses and to use the one that is smaller in value for system design.

(2) *Aperture Medium Coupling Loss.* Since the signals arrive at the receiver from an extended scattering volume, narrowing the antenna beam eventually reduces this common volume. Full antenna gain is thus not realized. As a result, a relative antenna gain-loss is incurred which has come to be known as the aperture medium coupling loss.

(a) The aperture medium coupling loss was first investigated by Booker[21] under the assumption of isotropic atmospheric turbulence and identical transmitting and receiving antennas. Staras[22] extended Booker's treatment to non-conical and non-identical antennas with due consideration of anisotropic atmospheric turbulence. Hartman[23] also gave a method for calculating this loss. These theoretical methods give different values.

(b) Experimental results reported by Chisholm[24], Crawford[25], and Angell[26] are plotted as a curve in Figure 1. Of all the theoretical estimates, Staras[22] seems to follow this experimental curve very closely. Since the aperture medium coupling loss is statistical in nature, the long term median value is important. All the values shown in Figure 1 are medians. It seems that much more experimental data are needed.

(3) *Medium Bandwidth.* The bandwidth which the scatter medium can support without serious distortion is again a very delicate matter. Several methods have been advocated for theoretical evaluation. Booker,[21] Crawford,[25] Gordon,[27] and Morrow[28] all define the medium bandwidth as the reciprocal of the multipath differential delay time between the two worst paths. The meaning of "worst paths," however, differs from one author to another. Staras[29] approaches the problem by considering the frequency correlation function. The bandwidth predicted by the others is from 6 to 7 times that predicted by Staras.

More investigation, both theoretical and experimental, is needed to solve this still controversial problem.

(a) Despite the controversial calculated values, all authors seem to agree that the degree of multipath delay or the bandwidth is controlled by the properties of the atmospheric irregularities for broad beam antennas (antenna beamwidth α much greater than the scattering angle θ; $\theta = \frac{d}{R}$ for smooth earth geometry, where d is the path distance and R is four-thirds of true earth radius) and by the antenna beamwidths for narrow beam antennas (α much less than θ).

(b) For illustrative purposes, calculated bandwidths by Booker and deBettencourt[21] are shown in Figure 2. For narrow antenna beam-

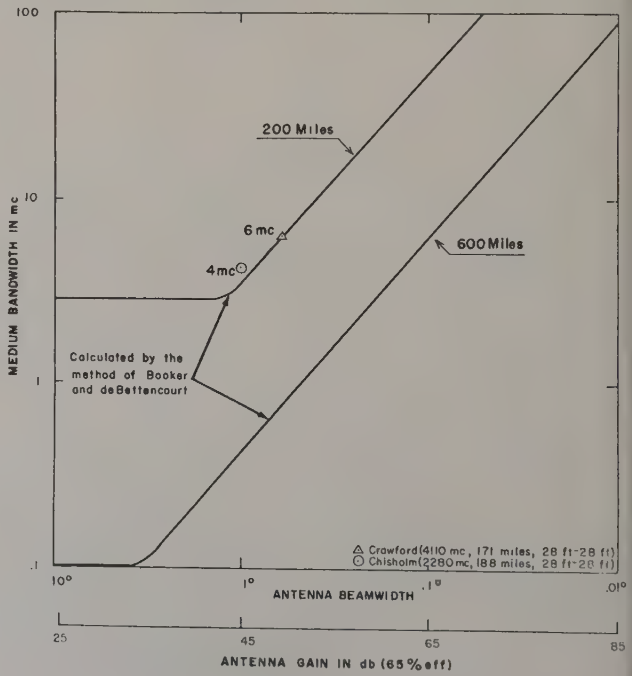

Figure 2 — Medium bandwidth.

widths, the bandwidth is inversely proportional to both path distance and beamwidth but more sensitive to the latter. Experimental points by Chisholm[24] and Crawford[25] were also plotted in Figure 2. The experimental values correlate with the theory quite well. No experimental data are available for longer paths. Figure 2 indicates that narrow antenna beams have to be used to obtain sufficient bandwidth. NOTE: The foregoing discussions apply to the use of AM (amplitude modulation) or SSB (single-sideband modulation) for radio transmission.

(c) For radio transmission by FM (frequency modulation) the multipath-delay will cause intermodulation distortion in frequency division multiplex systems. This will restrict the number of multiplex channels that can be used.

New Developments

The preceding paragraphs covered recent progress in he field of propagation. Systemwise, a few new developments are worthy of note.

(1) *Angle Diversity.* Using diversity reception to reduce fast fading is a very well known technique but, heretofore, only space and frequency diversities have been used.

Angle diversity[30] is a comparatively new application to scatter propagation and its main advantage is a saving in antenna cost. One method utilizes an antenna (for instance, a parabolic antenna) capable of producing a beamwidth of the order of a fraction of a degree. By the use of many feed-horns for illumination, this antenna will produce a multiplicity of beams, each at a different angle. Multiple diversity is thus obtained. Since some beams will point to non-optimum positions (optimum position is the great circle route at azimuth and radio horizon at elevation), the gain in diversity is obtained with the sacrifice of some median signals in individual beams. Further experimental study is needed to prove its practical value.

(2) *Low Noise Amplifiers.* Both maser and parametric amplifiers are low noise devices and therefore could be used as front ends to improve the sensitivity of a receiver.

Molecular beam masers, using gaseous molecules such as ammonia, have very little use in amplifier applications because of their small gain-bandwidth product, low power-output, and lack of tunability. The three-level, cavity-type, solid-state maser, using pink ruby as the paramagnetic material, is the most highly developed type at present. More advanced types, however, are traveling wave devices, which have substantial improvement in gain-bandwidth products. Noise figures approach 0-1 db. The greatest disadvantage of masers is the requirement of a cooling bath at a temperature of 1° to 4°K, usually achieved by the use of liquid nitrogen. Parametric amplifiers, of which there are three types; ferrite, semiconductor diode, and electron beam, utilize variable reactance devices. Compared with masers, all have a much greater dynamic range and bandwidth capability and do not require a low temperature bath or environment. They are more suitable for trospospheric-scatter systems. Noise figures approach 2-4 db. Table III contains brief summaries of the approximate noise figures for various types of amplifiers, including both conventional and low-noise devices.

TABLE III — Noise Figures of UHF Amplifiers

Type Amplifier	Frequency Range	Noise Figure
Triode	30-3000 mc	3-10 db
Semiconductor	300-1000 mc	1 db
TWT	3000-10,000 mc	4-10 db*
Maser	500-10,000 mc	0-1 db
Parametric	50-10,000 mc	2-4 db**

* *Recent development indicates that 4 db noise figure at 10,000 mc is feasible.*

** *Recent development indicates that 2 db noise figure at 400 mc is feasible.*

In using low-noise amplifiers, consideration should be given to the external noises such as terrestial and extraterrestial noise sources at various uhf frequencies. Hausman[31] has pointed out that not much gain results from using low noise devices in the 100-1000 mc ranges because of the high external noise level at these frequencies.

(3) *Fading Margin and Reliability.* Long-term system reliability may be determined from the combination of slow and fast fading distributions when the fading margin is known from the system parameters.

Since both distributions are statistical in nature, the use of a probability combination is natural and logical. This has been advocated[18] for the design

Typical tropospheric scatter communications station installed in Libya uses both the "billboard" and "dish" type tropo antennas at one site.

Photo courtesy of Page Communications Engineers, Inc.

TABLE IV — Fading Margin vs Reliability[33]

Parameters	Algebraic Combination						Probability Combination					
Path Length	100 mile			600 mile			100 mile			600 mile		
Scattering Angle	1.1 degree			6.6 degree			1.1 degree			6.6 degree		
Order of Diversity	1	2	4	1	2	4	1	2	4	1	2	4
Fading Margin in db (99% Reliability)	39	29	23	22	12	6	26	20	16	18	8	4
Fading Margin in db (99.9% Reliability)	56	41	33	33	18	10	38	28	26	30	15	6

of voice communication systems. It has been reported[16,33] that experimental results checked fairly well with theoretical probability-combined fading distributions.

An algebraic combination is still used for data and teleprinter transmissions. It may be explained by quoting Brennan[32], who said that computing the long-term combining distribution by means of probability functions tends to obscure the question of whether the periods of very low signals are a few long or many short ones. This question can be important, especially in data and teleprinter transmission; e.g., systems are in operation in which the loss of two hours in a year would not be troublesome if split into a number of separate intervals of a minute or two each, but which could be disastrous if concentrated in a single interval of two hours. The algebraic combination method requires a considerably greater fading margin than the probability combination method, especially at short path distances. A comparison is shown in Table IV.

(4) *Improved Design Techniques.* As mentioned earlier, certain fading margins must be allowed in the design of tropospheric-scatter systems according to the required reliability. These margins are usually provided by using large antennas and high transmitter rf power. Since the fading is statistical in nature, the ultimate capability of the system is utilized only for a very short time. Several methods have been proposed to improve the situation:

(a) *Controlled Carrier.*[33,34] The transmitted rf power is controlled as closely as possible in accordance with the fading conditions by means of a pilot tone transmitted through a closed servo-loop including the two-way transmission paths. This is equivalent to the application of an AGC to the transmitter instead of to the receiver. Such a scheme would result in an average primary power saving of up to 98%. However, the same transmitted rf power requirement with uncontrolled operation has to be provided.

(b) *Controlled Bandwidth*[35]. (Applicable to FM systems only) The IF bandwidth of the receiver is controlled by the traffic volume, which exhibits a considerable diurnal variation. In such a scheme the baseband power (varying as the traffic volume) is utilized as the control factor. This would result in improving the system reliability slightly or reducing the transmitter rf power requirement by about 3 db.

(c) *Controlled Threshold*[36]. (Applicable to FM systems only) This is similar to scheme (b) except that the receiver IF bandwidth is controlled by the fading conditions. In such a scheme the received rf power (varying with the fading conditions) is utilized as the control factor. This would result in reducing the transmitter rf power requirement by a few db, with a trade-off of either a degraded quality in the upper channels or a reduction in the number of useful channels.

(d) *Feedback Techniques*[37,38]. (These techniques have been extended to FM tropospheric-scatter systems.) The receiver IF bandwidth is compressed by a feedback loop which has the effect of reducing the noise bandwidth without impairing the system deviation improvement. (A combination of feedback and phase-locked detection has also been used.) This would result in reducing the transmitter power requirement by as much as 10 db.

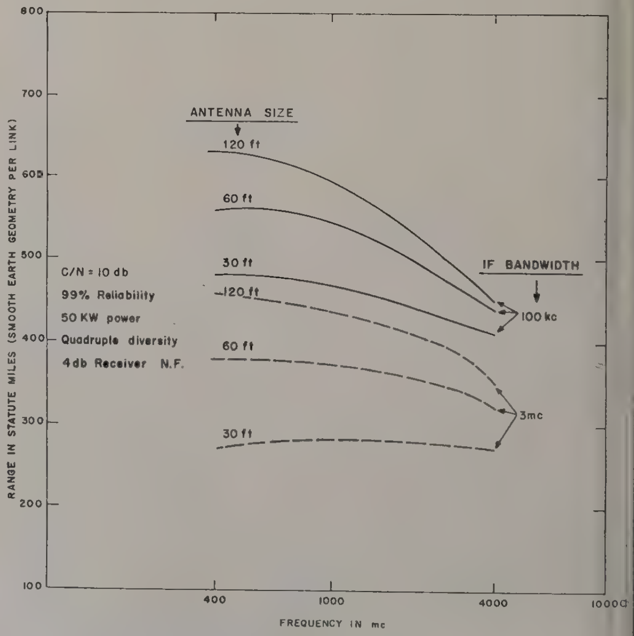

Figure 3 — Maximum capabilities (per link).

TABLE V — Tropo-Scatter Systems[42-48]

Country	USA[42,43]		CANADA[44,45,48]			NORWAY[46,47]
System	Bell System	White Alice	Pole Vault	Mid-Canada	Dew Drop	Part of Ace High
Location	Miami-Havana	Alaska	Newfoundland-Labrador	Quebec-Labrador	Cape Dyer -Thule	Oslo-Bodö
Frequency range (mc)	700-900	750-950	571-731	755-980	350-450	900-2200
Average power (kw)	10	1-10	10	2-10	10	10
Modulation	FM	FM	FM	FM	SSB	FM
Antenna (ft.)	60	30-60	60	30-60	120	30-60
Diversity	4	2	2	4	4	4
Radio channels	1	1	1	1	1	1
Spare channels	1*	1	1	0	0	0
Total channels	2	2	2	1	1	1
Voice channels per radio channel	36	12-72	12-36	36-108	24	36
TV channels per radio channel	1	0	0	0	0	0
No. links	1	23	9	5	1	3
Distance per link (miles)	185	100-200	130-228	90-137	690	100-200
Expected range (miles)	—	3000	2000	—	—	9000

* *Spare channel also used for TV transmission.*

(e) *Matched Traffic Technique*[39]. The hourly traffic volume is so controlled that the amount of traffic transmitted is matched to the fading conditions. The received rf power (varying as the fading conditions) is used to control both the IF bandwidth of the receiver and the traffic channels. This has the advantage of initial cost saving, as the system could be designed for the most urgent channels only — which usually amounts to a few percent of the ordinary traffic. The non-urgent traffic could be delayed and transmitted during improved conditions. The same technique could also be used for existing or future systems of conventional design to increase the number of channels during improved conditions.

Based on the above discussions, the maximum capabilities (on a per-link basis), of tropospheric-scatter circuits, at the present state of the art, are estimated somewhat as indicated in Figure 3. This figure is obtained by following the simple method[18] of system design. It can be seen that for long haul per link, frequencies in the range of 400-1000 mc should be used.

Frequency modulation (FM) is generally used in existing systems, although single-sideband modulation (SSB) systems[40,41] have been tested and advocated. Merits of FM and SSB systems are difficult to compare because of the various factors involved.

Table V lists some of the existing systems and indicates that the tropospheric-scatter mode of propagation has finally advanced from an experimental stage to become one of the established alternative means of microwave communication.

CONCLUSION

Microwave radio communication systems, either line-of-sight or tropospheric-scatter, have the wideband capability needed for the continuous expansion of telephone traffic and can meet the added requirement for global-coverage television transmission in modern times. This capability is so far unchallenged by any other means except the projected satellite relays.

As satellite relays will not be realized for commercial applications in the near future, a microwave radio communication system with both line-of-sight and tropospheric-scatter links seems to be the only means capable of providing wideband global communications for some time to come.

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A COOLED, NEGATIVE CONDUCTANCE, DEGENERATE PARAMETRIC AMPLIFIER*

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Introduction

The general theory of negative conductance devices has been thoroughly researched, and experimental investigations of parametric amplifiers have been carried out.[1,2,3] The analysis usually presented in these investigations couples two separately tuned resonant circuits by a time-varying capacity. The degenerate-type parametric amplifier discussed here, however, consists of one resonant circuit with a time-varying capacity (Figure 1). If the capacity is "pumped" at a frequency $2\omega_0$, a signal applied at a frequency $\omega_0 + \triangle\omega$ is amplified and another signal or "idle" is generated at a frequency $\omega_0 - \triangle\omega$.

It is shown in the appendix that, at resonance, the voltage appearing across the circuit at the same frequency as the source can be calculated if the circuit is replaced by a conductance of value

$$G = -\frac{1}{G_g}\left(\frac{\omega_0 C_1}{2}\right)^2 \qquad (1)$$

where

G_g = generator conductance

$\omega_0 = (LC_0)^{-1/2}$ = resonant frequency of circuit

C_1 = peak capacity variation.

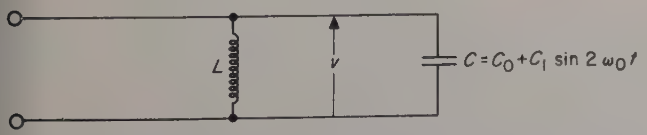

Figure 1 — Resonant circuit of degenerate parametric amplifier.

The value of G will be essentially constant over a narrow frequency range.

A successful configuration for negative conductance amplifiers involves a circulator and transmission line (Figure 2). If the circulator load, source and transmission line all have the same impedance, the available power gain g, defined as the output power of the signal divided by the available power from the source, is given by the square of the absolute value of the reflection coefficient.[4]

$$g = |\rho|^2 = \frac{\left(\frac{B}{G_g}\right)^2 + \left(1 - \frac{G_1}{G_g} - \frac{G}{G_g}\right)^2}{\left(\frac{B}{G_g}\right)^2 + \left(1 + \frac{G_1}{G_g} + \frac{G}{G_g}\right)^2}, \qquad (2)$$

where

G_1 = circuit loss

G = equivalent conductance of circuit

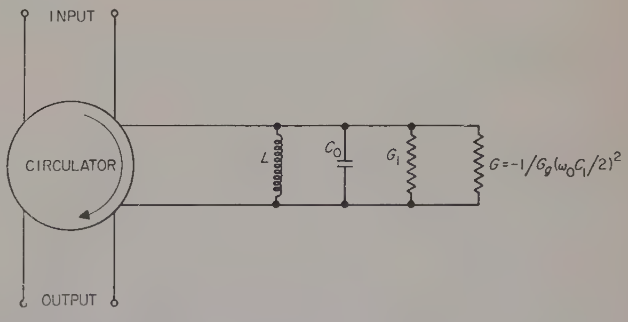

Figure 2 — Configuration of negative conductance parametric amplifier.

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*This paper presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under Contract No. NASw-6, sponsored by the National Aeronautics and Space Administration.

B = circuit susceptance.

If $\delta = (\omega - \omega_0)/\omega_0 << \omega_0$ and $B \simeq 2\delta\omega_0 C_0$,

$$g = \frac{\left(\frac{2\,\delta\omega_0 C_0}{G_g}\right)^2 + \left(1 - \frac{G_1}{G_g} - \frac{G}{G_g}\right)^2}{\left(\frac{2\,\delta\omega_0 C_0}{G_g}\right)^2 + \left(1 - \frac{G_1}{G_g} + \frac{G}{G_g}\right)^2} \,. \qquad (3)$$

The gain at resonance g_0 is obtained when $\delta \rightarrow 0$ and is given by

$$g_0 = \frac{\left(1 - \frac{G_1}{G_g} - \frac{G}{G_g}\right)^2}{\left(1 + \frac{G_1}{G_g} + \frac{G}{G_g}\right)^2} \,. \qquad (4)$$

The bandwidth BW (cps) is found by setting the ratio $(g/g_0) = 1/2$ and substituting for G from Equation (4) as follows:

$$BW = \frac{G_g}{\pi C_0 (1 + \sqrt{g_0})\,\sqrt{1\text{-}2/g_0}} \,. \qquad (5)$$

The noise figure F as measured by a noise source (double channel noise figure) is defined by

$$F = \frac{N_0}{g_0 k T_0 b} \,, \qquad (6)$$

where

N_0 = total output noise power
g_0 = power gain
$kT_0 = 4 \times 10^{-21}$ watts/cycle
b = bandwidth.

The bandwidth b will be twice BW as given by Equation (5), since there is an overlapping of the signal and idle response. The principal contributions to the output noise power are

$$g_0 k T_0 b \qquad (7)$$

from the source and

$$\frac{4kT\, G_g G_1}{(G + G_1 + G_g)^2} \qquad (8)$$

from G_1 if T is the temperature of G_1. Therefore,

$$F \simeq 1 + \frac{T}{T_0}\,\frac{4}{g_0}\,\frac{G_1 G_g}{(G_g + G_1 + G)^2} \,. \qquad (9)$$

Substituting for G from Equation (4),

$$F \simeq 1 + \frac{T}{T_0}\,\frac{G_1}{G_g}\,\frac{(1 + \sqrt{g_0})^2}{g_0} \,. \qquad (10)$$

The amplifier equivalent noise temperature T_r = (F - 1) T_0 is then given by

$$T_r = T\,\frac{G_1}{G_g}\,\frac{(1 + \sqrt{g_0})^2}{g_0} \,. \qquad (11)$$

If the antenna temperature is T_a, the system temperature T_s is given by

$$T_s = T_r + T_a \,. \qquad (12)$$

Equation (12) is applicable to radio astronomy and other modes of operation which utilize signals applied to both the signal and idle channels. For systems which use only signals applied to the signal channel, the system noise temperature is

$$T_s = 2(T_r + T_a) \,. \qquad (13)$$

For some applications, such as the electron beam parametric amplifier, the treatment of C as a simple time-varying element is proper. However, a varactor is actually a nonlinear element whose capacity is a function of the voltage applied. It has been shown[2] that this can be taken into account with an effective capacity change twice that produced by the pump alone. Therefore, in order to apply these equations to a varactor, it is necessary to make the substitution $\triangle C = C_1$, where $\triangle C$ is the peak-to-peak varactor capacity variation.

The varactor parameters can be optimized to give the lowest noise figure. If $\overline{R}$ and $\overline{C}$ are the mean series resistance and capacity of the varactor, $\overline{R} << (1/\omega_0\overline{C})$, and circuit losses are neglected,

$$G_1 \simeq \overline{R}(\omega_0 \overline{C})^2 \,. \qquad (14)$$

From Equations (1) and (4), again neglecting circuit losses,

$$G_g \simeq \frac{\omega_0 \triangle C}{2}\sqrt{\frac{\sqrt{g_0} + 1}{\sqrt{g_0} - 1}} \,. \qquad (15)$$

Then from Equation (11), the amplifier equivalent noise temperature in terms of varactor parameters is

$$T_r \simeq \frac{T}{g_0 K}\sqrt{(\sqrt{g_0} - 1)(\sqrt{g_0} + 1)^3} \,, \qquad (16)$$

where K is a varactor figure of merit given by

$$K = \frac{\triangle C}{2\omega_0 \overline{R}\,\overline{C}^2} \,. \qquad (17)$$

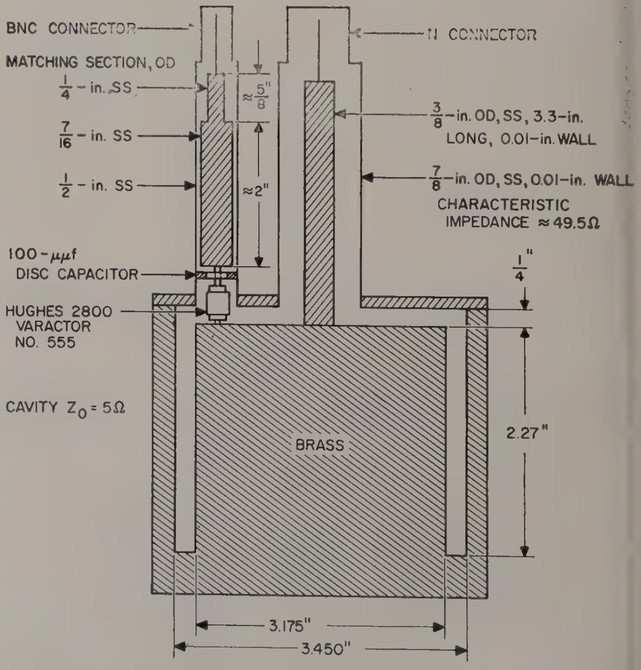

Figure 3 — Construction details of parametric amplifier.

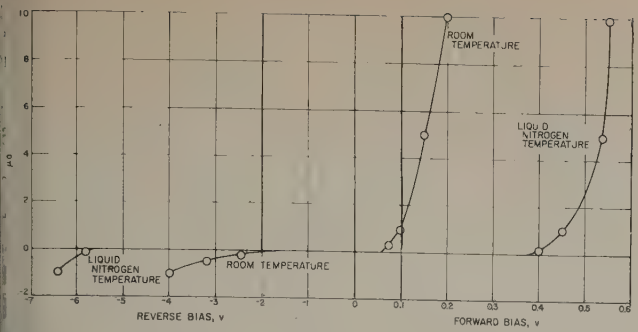

Figure 4 — Measured dc characteristics of Hughes germanium diode No. 555 used in experiment.

In amplifier noise temperature calculations it is obviously necessary to evaluate K from the actual operating conditions. However, there are several ways to specify the bias point and the total capacity swing over which K can be determined for varactor evaluation. Typically, the end points are chosen at which the varactor conducts 1 μa.[5] Another possibility, as shown in the evaluation for this paper, is to choose $\triangle C$ over the range of minimum $\overline{R}$.

Theoretical and Experimental Results

A 960 Mc parametric amplifier was constructed using a Hughes varactor-type 2810 and a coaxial 1/4 λ resonant cavity. Figure 3 shows the constructional details of the cavity, varactor mounting and the bias, signal, and pump feed. The low-impedance cavity is used so as to permit the varactor to be connected directly across the cavity. Direct coupling of the signal feed through a 1/4 λ matching section minimizes coupling losses. The impedance of the matching section can be changed to optimize the noise figure by varying the diameter of the center conductor. The cavity is immersed in liquid nitrogen to reduce the amplifier temperature T in Equation (11) to 78°K.

Figures 4 and 5 show how cooling the varactor affects the dc characteristics and the series resistance and capacity.

The bandwidth is calculated from Equation (5), using the cavity dimensions from Figure 3. The inductance L is given by

$$L = \frac{lZ_0}{3 \times 10^{10}},$$

where

l = cavity length, cm
Z_0 = cavity characteristic impedance

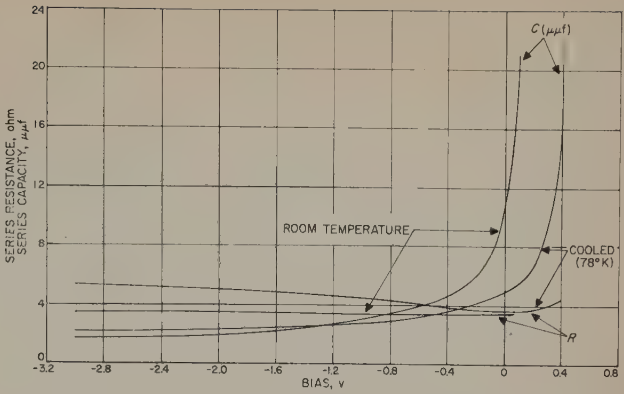

Figure 5 — Series parameters of Hughes germanium varactor No. 555 at 960 Mc, including bypass capacitor.

so that the total capacity C_0 is given by

$$C_0 = \frac{3 \times 10^{10}}{\omega_0^2 lZ_0} = \frac{3 \times 10^{10}}{(2\pi \times 960 \times 10^6)^2 (5.75)(5)} = 28.8\ \mu\mu\text{fd}.$$

The characteristic impedance of the quarter-wave matching section to the cavity is 49.5 ohms, giving

$$G_g = \frac{(49.5)^2}{50} = 49 \text{ ohms}.$$

Therefore, at 20 db gain, the calculated bandwidth is

$$BW = \frac{1/49}{\pi(28.8)(10^{-12})(11)\sqrt{1-2/100}} = 20.6 \text{ Mc}.$$

The amplifier noise temperature can be calculated from the data for the cooled varactor given in Figure 5. The total capacity swing required can be obtained from Equation (15). At 20 db gain,

$$\triangle C = \frac{2G_g}{\omega_0}\sqrt{\frac{\sqrt{g_0}-1}{\sqrt{g_0}+1}} = \frac{2(1/49)}{2\pi(960 \times 10^6)}\sqrt{\frac{9}{11}} = 6.1\ \mu\mu f.$$

With +0.1 volt forward bias used for the optimum experimental noise figure, the maximum and minimum capacitances can be found which satisfy $\triangle C = (c_{max} - c_{min})/2$ at + 0.33 and −0.13 volt to give

$$\overline{C} = \frac{c_{max} + c_{min}}{2} = \left(\frac{10.5 + 4.4}{2}\right) \mu\mu f = 7.45\ \mu\mu f$$

and

$$\overline{R} = \frac{R|_{-0.13v} + R|_{+0.10v} + R|_{+0.33v}}{3}$$

$$= \frac{3.70 + 3.65 + 4.00}{3} = 3.78 \text{ ohm}.$$

From Equation (17), the figure of merit of the varactor under these conditions is

$$K = \frac{6.1 \times 10^{-12}}{2(2\pi \times 960 \times 10^6)\ 3.78(7.45 \times 15^{-12})^2} = 2.42.$$

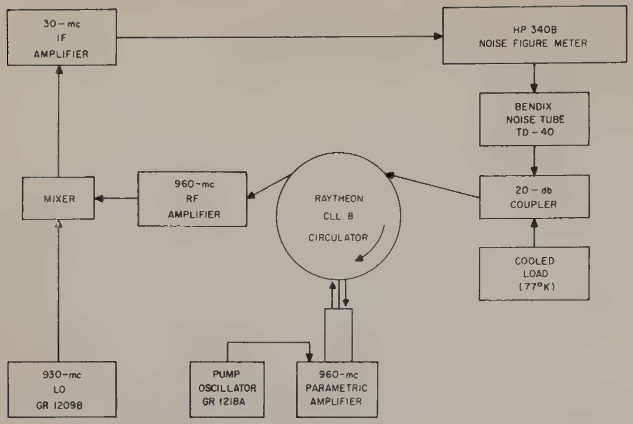

Figure 6 — Block diagram of parametric amplifier and associated equipment used in noise figure experiment.

The cooled amplifier noise temperature can now be calculated from Equation (16) as follows:

$$T_r = \frac{78}{100(2.42)} \sqrt{9(11)^3} = 35°K.$$

Figure 6 shows the experimental setup for noise figure measurements. The liquid-nitrogen-cooled termination increases the measurement accuracy.[6] Figure 7, which is a plot of gain and over-all noise figure versus input signal frequency, shows the 3 db bandwidth of the parametric amplifier to be about 20 Mc at 20 db gain and the over-all noise figure to be below 0.9 db over a frequency range greater than 10 Mc. Figure 8 is a plot of gain and over-all noise figure versus pump power; at the reasonable gain of 20 db, the noise figure is 0.82 db. Figure 9 is a plot of gain and over-all noise figure versus pump frequency for a nominal gain of 20 db.

The effect of impedance changes of the source and load is determined by coupling the signal through a 20 db coupler. Changing the VSWR of either the source or load impedance from 1.06 to 1.4 changes the gain less than 1 db.

At 20 db gain, a noise figure of 0.82 db corresponds to an equivalent over-all noise temperature of 59°K. The circulator contributes about 11°K, so that the amplifier noise temperature is approximately

$$59 - (12 + 11) = 36°K.$$

The experimental setup shown in Figure 10 is used for a measurement of gain stability. The recorder is calibrated by recording the dc output with the noise tube fired and not fired. The short-term stability (several minutes) is about 1°K. The drift per hour is typically several degrees Kelvin. For this setup, a one degree drift represents a gain instability of less than one per cent.

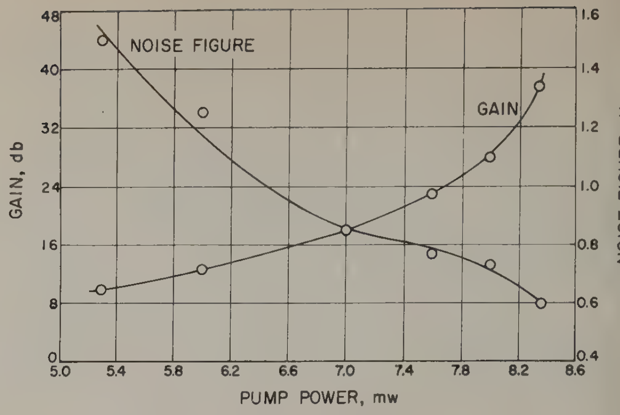

Figure 8 — Gain and noise figure vs pump power.

Summary

A simple theory has been given for calculating the performance of a degenerate parametric amplifier in terms of measurable circuit and varactor parameters. Since the idle and signal frequencies are at approximately the same frequency, only one resonant circuit is required. Construction details were given for an amplifier in which the cavity and varactor are both cooled with liquid nitrogen. The equivalent noise temperature of the amplifier is derived in terms of a figure of merit for the varactor. Measurements of the parameters for the Hughes germanium varactor used in the amplifier were plotted to show that cooling to liquid nitrogen temperature is not detrimental.

Experimental curves were shown relating amplifier gain and noise figure to signal and pump frequency and pump power. The measured amplifier bandwidth and noise temperature of 20 Mc and 36°K agree very well with the calculated values of 21 Mc and 35°K. Bandwidth can be increased by raising the characteristic impedance of the cavity. Varactors with a higher figure of merit are needed to lower the amplifier noise temperature further.

It is indicated that the system temperature for coherent

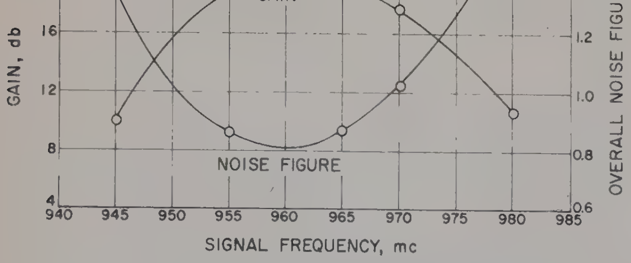

Figure 7 — Gain and noise figure vs signal frequency.

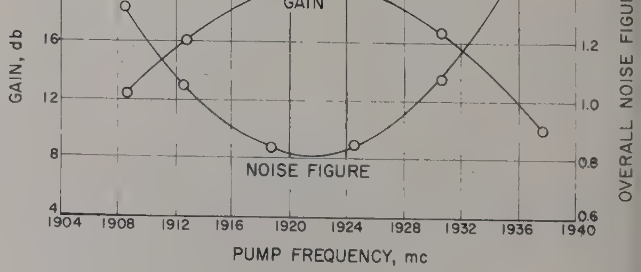

Figure 9 — Gain and noise figure vs pump frequency.

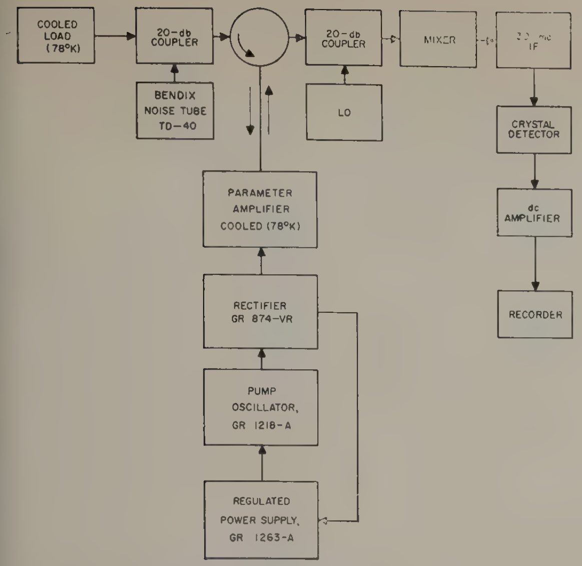

Figure 10 — Experimental setup for measurement of the parametric amplifier gain stability.

signals is twice the sum of the measured antenna and receiver temperatures for a degenerate parametric amplifier. For example, with an antenna having an equivalent noise temperature of 20°K, this amplifier, with an 11°K circulator and a 4°K postamplifier contribution, would have a system noise temperature of

$$2(20+36+11+4)=142°\text{K},$$

thus demonstrating its feasibility in applications such as radio astronomy, in which both the signal and idle channels are used and the noise temperature for the above example would be 71°K.

Ingvesson[7] has reported a .9 db receiver noise figure with a 4 Mc bandwidth at 20 db of gain for a negative resistance parametric amplifier pumped at X-band. This amplifier was not cooled and used a Microwave Associates varactor in a waveguide cavity. In comparison with the above example, this would represent a system temperature of

$$20+290(1.23-1)=87°\text{K}$$

applicable to either radio astronomy or coherent signal use.

Acknowledgment

Kenneth Wallace performed much of the experimental work in this investigation. William C. Pilkington contributed suggestions which aided the theoretical and experimental progress.

APPENDIX

For the circuit of Figure A-1

$$G_g(v-e)+\frac{1}{L}\int v\,dt+\frac{d}{dt}(Cv)=0. \qquad \text{(A-1)}$$

Substituting $x = \int v\,dt$ reduces this to

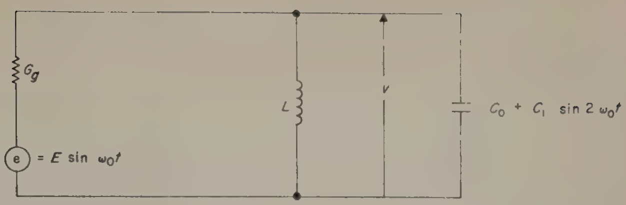

Figure A-1 — Configuration of circuit elements used to evaluate equivalent negative conductance.

$$G_g\dot{x}+\frac{x}{L}+C\ddot{x}+\dot{x}\dot{C}=eG_g. \qquad \text{(A-2)}$$

Assume that

$$x=A_1\sin\omega_1 t+B_1\cos\omega_1 t+A_2\sin\omega_2 t+B_2\cos\omega_2 t \qquad \text{(A-3)}$$

where

$$\omega_1=\omega_0+\triangle\omega$$

$$\omega_2=\omega_0-\triangle\omega.$$

Then if $(\triangle\omega)/\omega_0<<1$,

$$\dot{x}=\omega_0(A_1\cos\omega_1 t-B_1\sin\omega_1 t+A_2\cos\omega_2 t-B_2\sin\omega_2 t) \qquad \text{(A-4)}$$

$$\ddot{x}=-\omega_0^2 x.$$

Substituting Equations (A-3) and (A-4) in (A-2) and equating trigonometric terms results in

$$-B_2\omega_0+B_1\frac{\omega_0^2C_1}{2\,G_g}=0$$

$$-B_1\omega_0+B_2\frac{\omega_0^2C_2}{2\,G_g}=E$$

$$\text{(A-5)}$$

$$A_2\omega_0+A_1\frac{\omega_0^2C_1}{2\,G_g}=0$$

$$A_1\omega_0+A_2\frac{\omega_0^2C_1}{2\,G_g}=0.$$

Solving for the constants gives

$$A_1=0$$

$$\text{(A-6)}$$

$$B_1=-\frac{E/\omega_0}{1-\left(\frac{\omega_0C_1}{2\,G_g}\right)^2}$$

$$A_2=0$$

$$\text{(A-6)}$$

$$B_2=-\frac{E/\omega_0\left(\frac{\omega_0C_1}{2\,G_g}\right)}{1-\left(\frac{\omega_0C_1}{2\,G_g}\right)^2}.$$

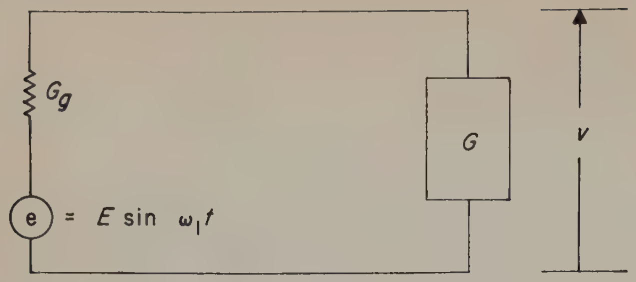

Figure A-2 — Resonant circuit replaced by an equivalent conductance.

Substituting the constants into Equation (A-4)

$$v = x = \frac{E \sin \omega_1 t}{1 - \left(\frac{\omega_0 C_1}{2 G_g}\right)^2} + \frac{E \sin \omega_2 t \left(\frac{\omega_0 C_1}{2 G_g}\right)}{1 - \left(\frac{\omega_0 C_1}{2 G_g}\right)^2} \qquad (A\text{-}7)$$

From Figure A-2

$$G = -G_g \left(1 - \frac{e}{v}\right) . \qquad (A\text{-}8)$$

Therefore, the equivalent conductance at ω_1 is given by

$$G = -G_g \left[1 - \frac{E \sin \omega_1 t}{\left[\frac{E \sin \omega_1 t}{1 - \frac{\omega C_1}{2 G_g}^2} \right]} \right] = - \frac{1}{G_g} \left(\frac{\omega C_1}{2} \right)^2 . \qquad (A\text{-}9)$$

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METHODS OF USING PURE NOBLE GAS IN GAS SWITCHING TUBES

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The use of a high purity noble gas in gas switching tubes, such as used in pulsed radar system duplexers, is relatively new. The advent of very high power, long range, radar systems has been largely responsible for the work in this field.

The majority of the tubes made in past years, as well as the majority of tubes still used in lower power equipments, use a mixture of a pure noble gas, such as argon, in combination with a controlled amount of an attachment gas, such as water vapor, to produce a rapid recovery time. Although many other combinations of gases are possible, and have been used in certain applications, historically, the argon-water vapor system has been the most widely used.

The need for a predictable recovery time arises from the fact that return signals from targets must pass through the switching element without serious attenuation, at a time represented by the system minimum design range. In short range systems the absolute recovery time must be in the order of a few microseconds. In long range systems the absolute recovery time need only be in the order of hundreds of microseconds.

It is usual to consider the recovery time point as that time at which the attenuation of a low level signal is equal to three decibels. However, it is easily realized that a single point cannot adequately describe the recovery performance of a gas switching tube. If a small target is considered with its very low signal return, even a small amount of attenuation can reduce this return below the level of receiver sensitivity. Therefore, in both long and short range situations the shape of the attenuation-time curve between three decibels and zero decibels attenuation is of great importance if it is desired to locate small nearby targets.

In any gaseous deionization process the actual recovery mechanism is complicated. Several mechanisms are operating simultaneously at rates that vary with time. However, the slopes of the attenuation-time curves indicate, in general, the predominant mechanism since the attenuation may be considered to represent electron density. The general equation for gaseous deionization is $\frac{\partial n}{\partial t} = v_i n - v_a n - \alpha n^2 - \triangle \cdot \Gamma$ where n is the electron density, v_i is the ionization rate coefficient, v_a the attachment rate coefficient, α the recombination rate coefficient and $\triangle \cdot \Gamma$ the diffusion rate. Since the recombination rate is a function of n^2, it produces fast deionization immediately following the pulse but the rate decreases rapidly with time. Most deionization curves seem to follow this general trend at the start, so that recombination is probably the predominant mechanism at the beginning in most recovery time cases. However, the attachment and diffusion mechanisms are largely responsible for the shape of the curve after the initial deionization has taken place since they are a function of n. The three processes therefore considered in the following discussion are attachment, recombination and diffusion.

The most widely used attachment gas is water vapor. The use of water vapor in a gas switching tube imposes serious limitations on the power handling capabilities of the switching element. The water vapor, or in general any attachment gas, produces deionization at the most rapid rate of the three recovery time mechanisms. Because deionization occurs during the transmitter pulse, as well as after the pulse, it follows that an increased amount of energy must be supplied to sustain the ionization during transmission. This additional energy, called arc loss, is translated almost entirely into thermal energy. Even though the arc loss is only a small percentage of the total transmitted power, in very high power systems, this added heat can cause rapid, catastrophic, failure of the switching element. It is, of course, possible to consider other attachment gases having a lower attachment cross section to increase the ability to handle high power.

One other problem that exists is the relatively greater chemical activity of attachment gases in the ionized state. This activity causes a loss of this component with life

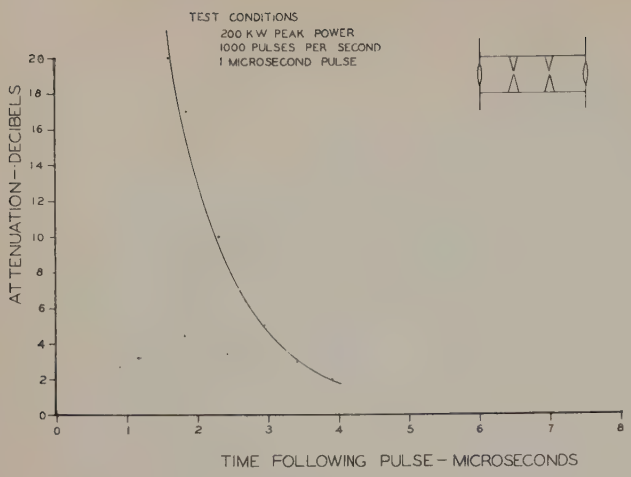

Figure 1

and a more rapid degradation of electrical performance. Thus the usual attachment mechanism, while quite useful for low power, short range, systems does not fit the requirements for high power long range systems.

Figure 1 shows the attenuation-time curve obtained in a typical gas switching tube using water vapor as the recovery time agent.

The probable upper limit, in X-band for example, for this attachment mechanism is about 500 kilowatts peak power and 500 watts average power.

The deionization process of recombination in a pure noble gas such as argon proceeds at a fairly rapid rate when the electron density is high, but at lower electron density levels, those which produce less than three decibels of attenuation, the rate becomes slow. Thus while the attenuation may reach the three decibel point in an adequate amount of time the additional time required to reduce the attenuation to a fraction of a decibel is such that small targets may be unobservable. This fact causes a limitation on the use of recombination as the only recovery mechanism.

The remaining mechanism for deionization and the one used in some high power equipments today is diffusion. In order to achieve reasonable recovery time in pure noble gases by diffusion it is necessary to provide neutralizing surfaces for the free electrons in or near the discharge region. This effect has been achieved in many ways with finely divided dielectric material to provide a large surface area, but usually very fine quartz fibers are distributed throughout the gaseous discharge volume. While this method achieves the desired result in several tube types, it has some defects. It is difficult to obtain and maintain the uniform distribution of quartz "wool" desired. In some cases the channeling of the arc discharge through the least dense paths in the quartz wool causes actual fusion of the quartz fibers. Tubes containing quartz wool are difficult to exhaust properly because of an adherent layer of water vapor on the very large surface area. In some tubes using the quartz wool technique the residual water vapor may actually provide the deionization rate credited to the quartz wool itself.

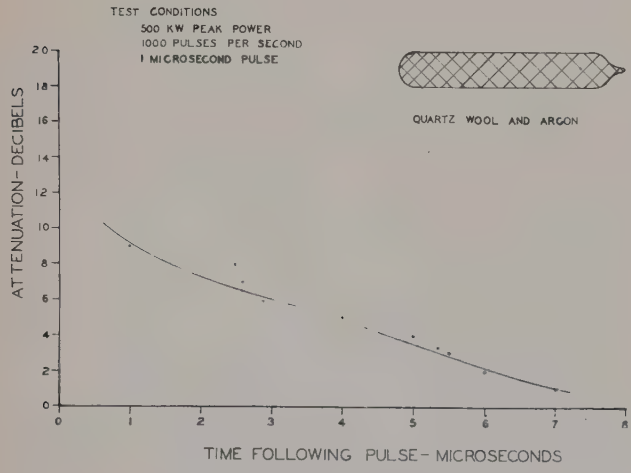

Figure 2

Figure 2 shows the recovery time curve of a simple cylinder containing quartz wool and pure argon mounted in a resonant plate.

The probable upper limit, in L-band for example, for this particular configuration is about 2 megawatts peak power and 2 kilowatts of average power.

A second and superior method of utilizing the diffusion process for recovery time has been achieved with the folded cylinder TR tube.* This tube is essentially a Dewar flask with the controlled spacing between the inner and outer cylinders. The recovery time in this design is determined by the gas used, the fill pressure, and the annular gap spacing. All of these factors can be accurately controlled and are consequently reproducible. A large surface area-volume ratio is maintained which not only produces the required recovery time but also allows efficient heat removal.

The end bulb provides a gas reservoir to maintain the tube characteristics during life and this volume is shielded from the microwave energy to prevent direct ionization.

Although concentric cylinders have been chosen for most of the work in this field to date, this configuration is largely a matter of convenience and structural stress characteristics. The same results can be realized with any restricted gas volume such as produced by two flat parallel plates with the gas contained between.

The attenuation-time curve of Figure 3 is that of a typical folded cylinder with a pure argon fill.

The upper power limit for the folded cylinder has not been determined but is greater than tens of megawatts peak power and hundreds of kilowatts of average power.

In order to reduce the energy required to produce ionization in a folded cylinder it has been found desirable to add a keep alive as in many conventional tubes.

When the idea of a keep-alive electrode was first proposed for folded cylinder tubes, a central location for the electrode was believed necessary. An electrode and its connecting lead in such a position, however, seriously disturbs both low and high level tube operation. This geometry increases low level insertion loss, introduces a source of noise ahead of the receiver, encourages ex-

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* *A New Concept in Microwave Gas Switching Elements,* Ray S. Braden; *PGED Conference, Washington, D.C., October 1957.*

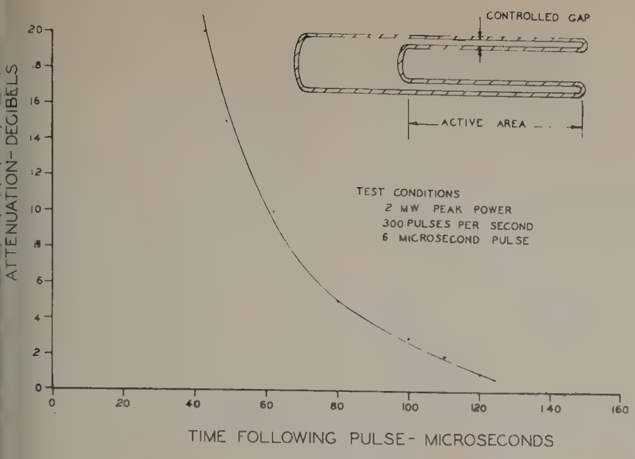

Figure 3

cessive sputtering, and is vulnerable to high voltage flashover.

In its present state of development the improved folded cylinder TR tube contains two electrodes arranged to form a small gap at the open end of the tube. An external direct current supply energizes the gap and provides a source of electrons. This keep alive arrangement produces the large drop in minimum firing power indicated in Figure 4 which compares folded cylinder windows with and without keep-alive electrodes.

This reduction in minimum firing power extends the advantages of folded cylinder tubes down to duplexers operating at a few kilowatts peak power. The lower operating limit depends upon transmitter frequency and tube dimensions.

Because the folded cylinder window is a broad-band low-Q device, the small keep alive discharge current of about 150 microamperes produces no measurable increase in low level insertion loss or noise figure. Since the keep-alive ionization region is far enough removed from the high field region of the tube, there is also no detectable effect upon recovery time.

Although folded cylinder tubes containing keep-alive electrodes are useful in branched duplexers, they offer a special advantage in dual TR tube balanced circuits. In this application, the variations in minimum firing power between plain folded cylinder tubes cause unbalance in the leakage power passing through each side of the output hybrid. This unbalance decreases receiver isolation from the transmitter.

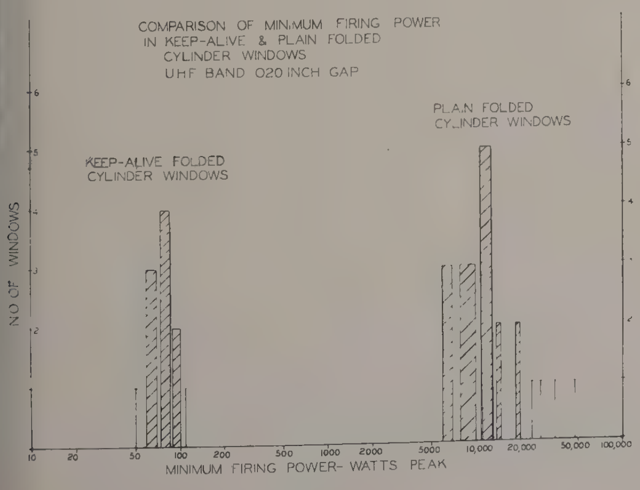

Figure 4

An obvious solution to this problem is to extend a single folded cylinder tube through both waveguides. Folded cylinder windows of this type have been successfully constructed and operated in the 5500 megacycle region, but this approach rapidly becomes unfeasible at lower frequencies. At 400 megacycles, as an extreme example, close diameter tolerances would have to be maintained over inner and outer sleeves about 38 inches long. It is easier and less costly to use two folded cylinder tubes with keep-alive electrodes in balanced duplexers. Despite slight differences in gas fill pressure or resonant iris dimensions, the keep alive discharges effectively synchronize the rate of plasma formation in the two tubes, and maintain the required balanced condition. Comparative data for a balanced duplexer containing folded cylinder tubes with and without keep-alive electrodes are shown in Figure 5.

To date, there is no complete explanation to account for the significant improvement in folded cylinder tube operation due to off-center keep-alive electrodes. The following qualitative relations between keep-alive operation and the propagation of electromagnetic waves in waveguide are offered as a starting point for an explanation of this complicated process.

The dominant mode of propagation in rectangular waveguide is the familiar TE_{10} mode. In this mode, the electric field intensity is a maximum at the center of the waveguide. When energy in this mode encounters a plain folded cylinder window located perpendicular to the electric field, plasma formation begins at this central region. However, the diffusion mechanism which accounts for the short recovery time of the folded cylinder also reduces the number of free electrons available to start the discharge. This is believed to account for the high values of minimum firing power and spike leakage observed in plain folded cylinder tubes that have a gap spacing of the order of 0.02 inch.

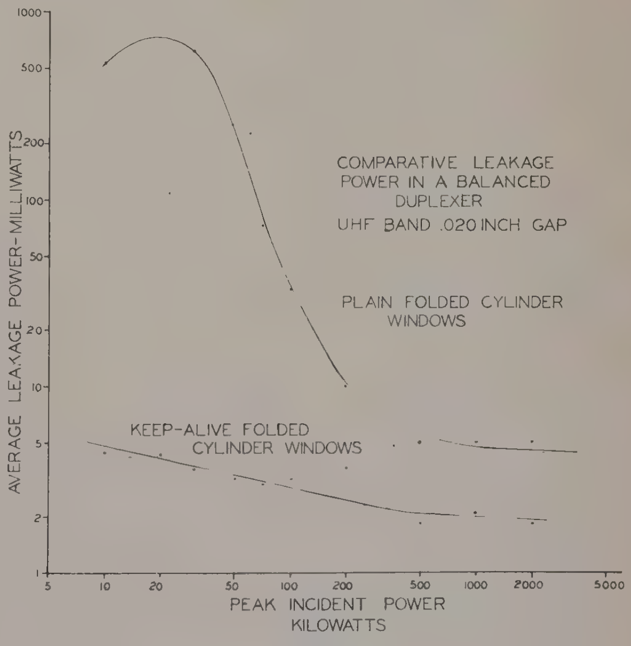

Figure 5

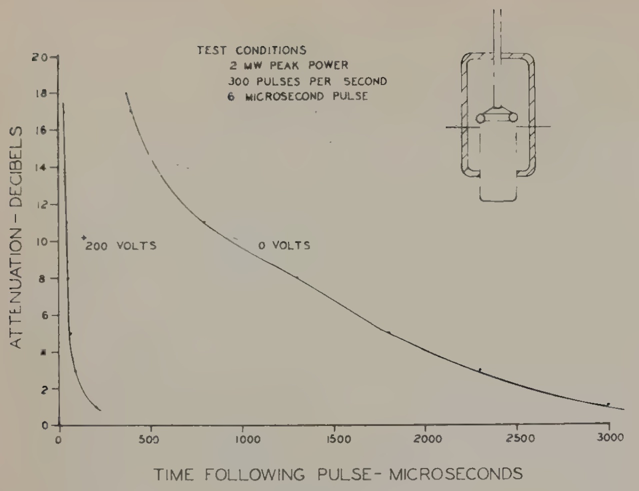

Figure 6

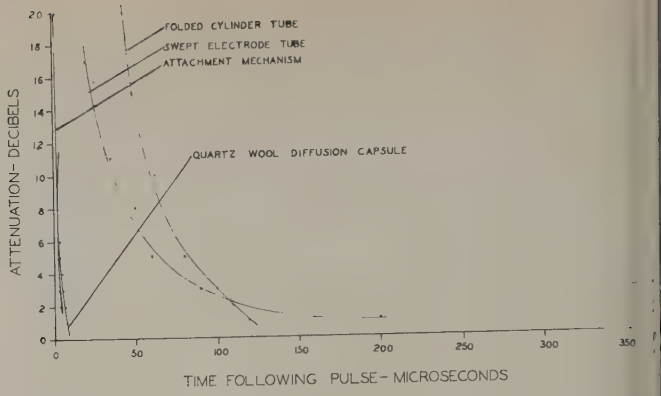

Figure 7

In the folded cylinder tube with keep-alive electrodes, on the other hand, there is a good supply of free electrons at one end of the tube. Some of these electrons drift away from the electrodes because of the potential difference between the electrodes and the mounting plate. The means by which these electrons reach positions to initiate rapid plasma formation are not fully understood. It would appear that there exists a transverse component of electric field between the end and center of the resonant slot which contributes to the process. The possible effects of higher-order waveguide modes on the rate of plasma formation are beyond the scope of this paper.

A third method of achieving the required recovery time utilizes a sweeping electrode biased positively to remove the electrons from the interaction space. Tubes of this type are used in coaxial transmission line duplexers and this design is credited to M.I.T. Lincoln Laboratories.

The use of the sweeping electrode is primarily useful in a tube design where the gaseous ionization is confined to a limited volume such as in the capacitive gap structure shown in Figure 6. If the discharge spreads considerably, as can occur if such a tube is used with long pulses, the sweeping electrode is no longer particularly effective. The free electrons continue to drift into the interaction space and the recovery curve approaches the zero bias condition. The two recovery time-attenuation curves illustrate the effects of the bias electrode. The zero bias condition represents recovery by recombination as the predominant mechanism. When a positive voltage of about 200 volts is applied the principal recovery mechanism is that of diffusion. For purposes of comparison, Figure 7 shows the attenuation-time curves of three methods of producing satisfactory recovery time in pure noble gases together with an attachment mechanism recovery curve on the same time scale.

It may be seen from these curves that the more rapid recovery time mechanisms are generally unsuitable for very high power because of the associated arc loss. In very general terms the water vapor attachment mechanism has a power handling capability about one tenth of the quartz wool filled capsule and this capsule has a power handling capability of about one tenth that of the folded cylinder tube.

Thus it has been shown that a pure noble gas may be used to provide the required characteristics for a gas switching tube to be used in high power long range radar systems. The predominant initial deionization mechanism is recombination, the predominant mechanism in the later stages is diffusion. The diffusion may be obtained in three ways: by a finely divided inert material interspersed in the gas volume, by a sweeping electrode to control diffusion, and by a restricted gas volume such as the folded cylinder tube.

The sweeping electrode tube has been used largely in coaxial transmission line duplexers with the tube providing the capacitive gap at the center of a half-wavelength coaxial cavity.

The folded cylinder tube can be adapted to almost any form of microwave circuit and has consequently received considerable usage. The major application to date is as a gas switching window or Pre-TR in waveguide systems. The addition of keep-alive electrodes improves the operation of folded cylinder tubes in balanced circuits and also extends their power operating range down to a few hundred watts.

In conclusion, the authors wish to acknowledge the assistance of their co-workers in the preparation of this paper.

COMPACT, MULTIHOLE, WAVEGUIDE DIRECTIONAL COUPLERS

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INTRODUCTION

Microwave system design often requires compact waveguide directional couplers with coupling values from 10 to 3 db, but high directivity is not required. Crossguide couplers, although compact, cannot be realized with coupling values much less than 20 db. Small couplers of 10 db or less are available that operate over a portion of the waveguide band. The couplers described here have coupling values as tight as 3 db and operate over the entire waveguide band, with a minimum directivity of 25 db. An overall length of 6-7/8 inches is typical in X-band. Design information for these compact couplers, as well as other types of couplers, is presented.

COMPACT DIRECTIONAL COUPLER TECHNIQUES

Broadwall, high-directivity, directional couplers generally have two arrays of coupling holes, with the centerline of each array located 0.203a[1] from the nearest sidewall as shown in Figure 1. High directivity couplers use a large number of small diameter holes, general 20 to 22 holes per array. The holes are spaced a quarter-guide-wavelength apart. Also, a very low VSWR termination is used in the isolated arm so as not to degrade the inherent high directivity.

One of the techniques of reducing the size of directional couplers is to make the holes larger in each array, which increases the total coupling. Therefore, the number of holes can be reduced to keep the coupling at a specific value. Since the holes are spaced a quarter-guide wavelength apart, the fewer number of holes required per array to achieve the desired coupling allows the overall length of the coupling section to be reduced by that number of quarter-guide wavelengths.

Another size reduction technique is the use of a short termination in the isolated arm. Miniature terminations are commercially available.

If the facilities for accurate bending of waveguide are not readily available, it is very convenient to use electroformed, or cast, bends. Accurate waveguide bends are often required, such as in balanced systems. The use of preformed bends does allow for a slight size reduction as compared to bends made by bending the waveguide.

Another method of reducing the size of waveguide couplers is to use half-height waveguide. This will only reduce the size of the coupler, but transitions will have to be used if this coupler is in a full-height system. Examples of these techniques are shown in Figure 2.

DESIGN OF COMPACT MULTIHOLE WAVEGUIDE DIRECTIONAL COUPLER

The coupling equations for narrow-wall and broadwall couplers were presented in the August 1959 *microwave journal.*[2] These equations were solved and experimentally

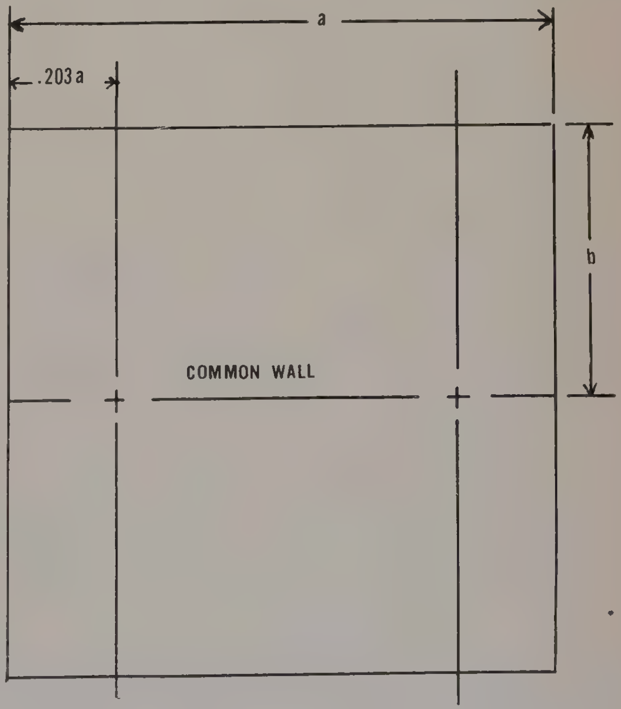

Figure 1 — Location of the centerline of each array.

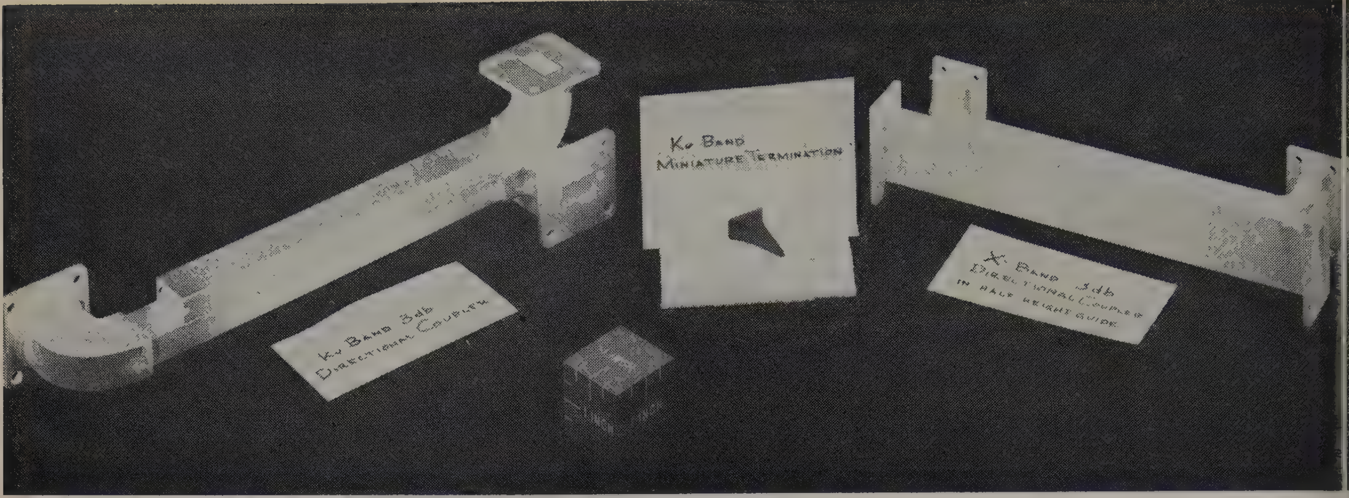
Ku Band Miniature Termination
Ku Band 3db Directional Coupler
X-Band 3db Directional Coupler in Half Height Guide

Figure 2.

checked. A slight modification was found necessary for values between 30 and 35 db coupling-per-hole. The experimentally determined curve for X- and Ku-band is shown in Figures 3 and 4. For compact coupler design, the controlling factor of the largest possible hole is the quarter-wavelength spacing between the centers of each hole. A thin wall must remain between each hole. The practical lower limit of wall thickness has been found to be about .010-inch as shown in Figure 5. Below this wall thickness, machining becomes difficult because the metal has a tendency to bend and distort the round hole. Also, it has been determined that with less than ten holes-per-array, the directivity across the waveguide band is less than 25 db at certain points. Therefore, a minimum of ten holes-per-array, or at least a total of 20 holes, is used in the design of these couplers. However, for tight coupling, more than 20 holes must be used in order to obtain the desired coupling as shown by the following example.

Example: Design a 3-db Ku-band directional coupler

K_T — total coupling

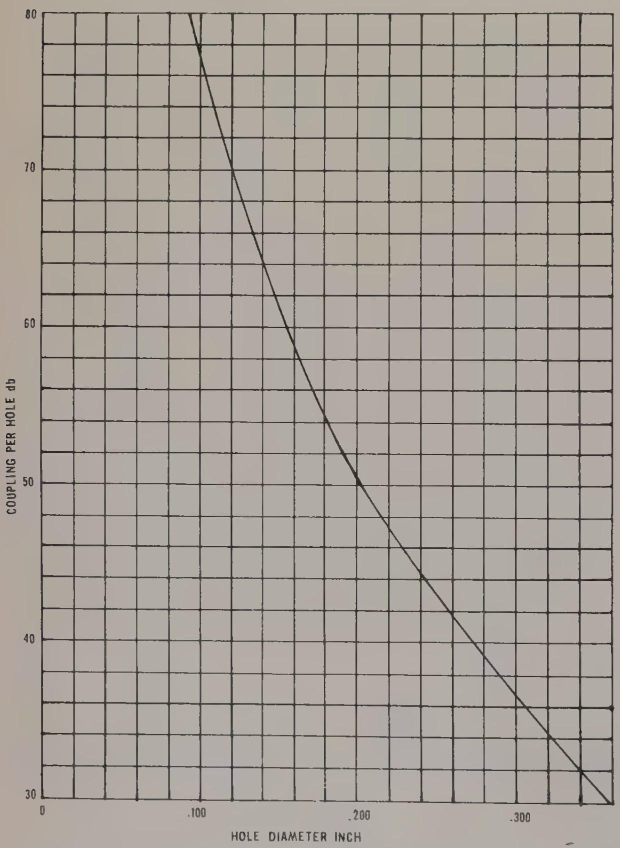

Figure 3 — Coupling per hole db for X-band broadwall waveguide directional couplers at 10.2 kMc. Holes are .383 apart. Each array is located .233 from the outside edge of RG-52/u waveguide.

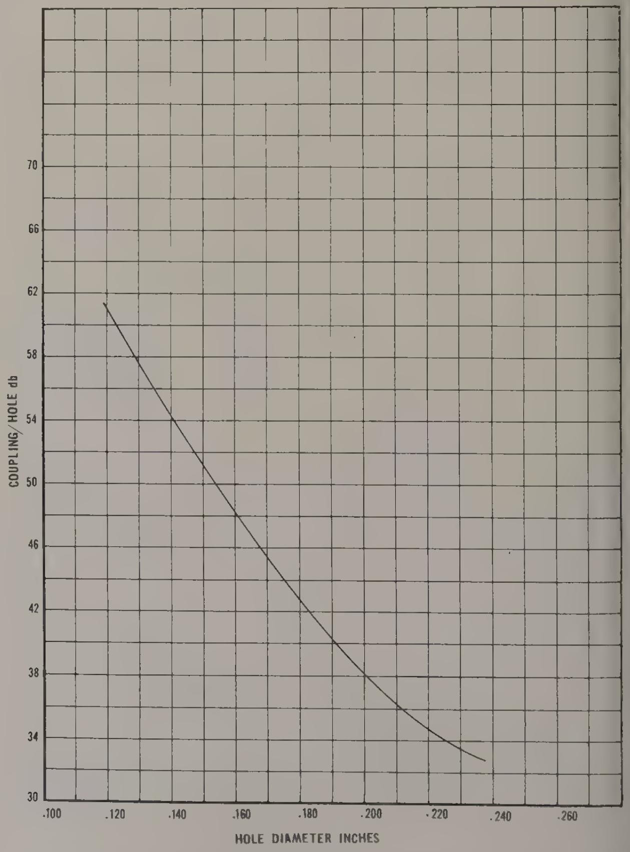

Figure 4 — Coupling/hole for Ku-band broadwall directional couplers at 15 kMc. Holes are .252 inches apart. Each array is 0.166 inches from outside wall of RG-91/u waveguide.

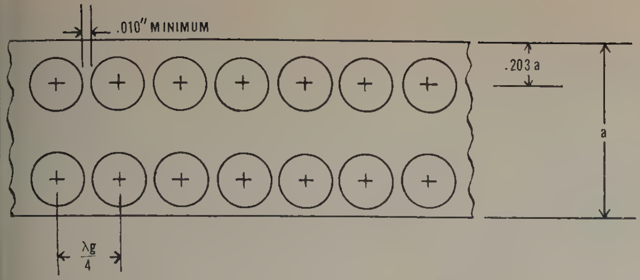

Figure 5 — Critical dimensions of a broadwall directional coupler.

n — number of holes-per-array
K — coupling value of each hole
$K_T = 2nK$

All holes are to be equal diameter. As a starting point, assume ten holes-per-array, or

$$707 = 20\ K$$
$$K = .03535 \text{ or } 29.05 \text{ db}$$

Referring to Figure 4, it is seen that this is impossible to obtain. It is easily found that the minimum number of holes is 16-per-array. Therefore, the coupling-per-hole is

$$.707 = 32\ K$$
$$.0220 = K \text{ or } 33.5 \text{ db.}$$

Referring to Figure 4, the proper diameter is found to be 0.235 inch.

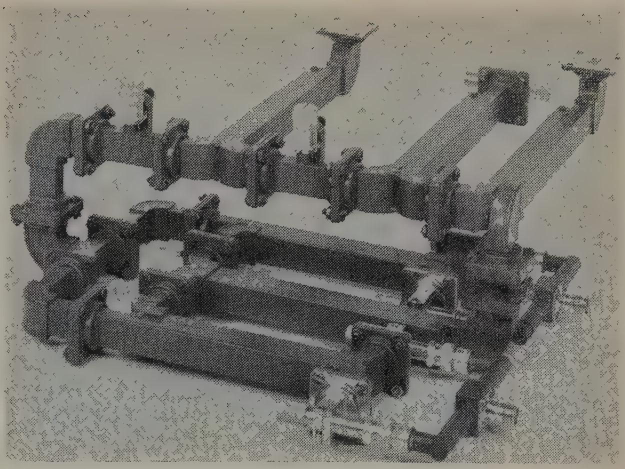

Figure 6 — Ku balanced mixer outphasing unit.

Figure 6 shows a Ku-band balanced mixer receiver front end system. The system features an image cancellation or suppression principle which is quite sensitive to non-uniformity among couplers. All of the couplers, four 3-db couplers, and two 9-db couplers, were designed from Figure 4. All of the 3-db couplers have the same coupling curve within 0.1 db, and the directivity is greater than 25 db. The 9 db ±0.25 db couplers have a minimum directivity of 26 db. The minimum suppression of this unit is 18 db. This unit utilized electroformed bends. The importance of precision bends was demonstrated by comparing the performance of the system shown in Figure 6 with that obtained with a similar X-band system that used conventional, mandrelformed bends. The best performance realized from the latter, even after a considerable amount of shimming at various points within the circuit was 6 db poorer. The circuit utilizing preformed bends operated satisfactorily without shims, just as it came from the shop.

COMPARISON OF COMPACT COUPLERS TO PRESENT COMMERCIAL COUPLERS.

X-BAND

	Compact Couplers				
	Half-Height Waveguide Couplers		Full Height Waveguide Couplers		Typical Commercial Couplers
Frequency Range	8.2-11 kmc	8.2-11 kmc	8.2-11 kmc	8.2-11 kmc	8.2-12.4 kmc
Coupling	3 db±.3 db	14 db±.2 db	3 db±.3 db	10 db±.2 db	3 db±.5 db
Min. Directivity	25 db	28 db	26 db	30 db	40 db
Length	6-1/4″	6-1/4″	6-7/8″	6-1/2″	16-11/16″

Ku-BAND

	Compact Full Height Waveguide Couplers	Typical Commercial Couplers
Frequency Range	12.4-18 kmc	12.4-18 kmc
Coupling	3 db±0.3 db	3 db±0.5 db
Min. Directivity	25 db	40 db
Length	6-5/8″	13-3/4″

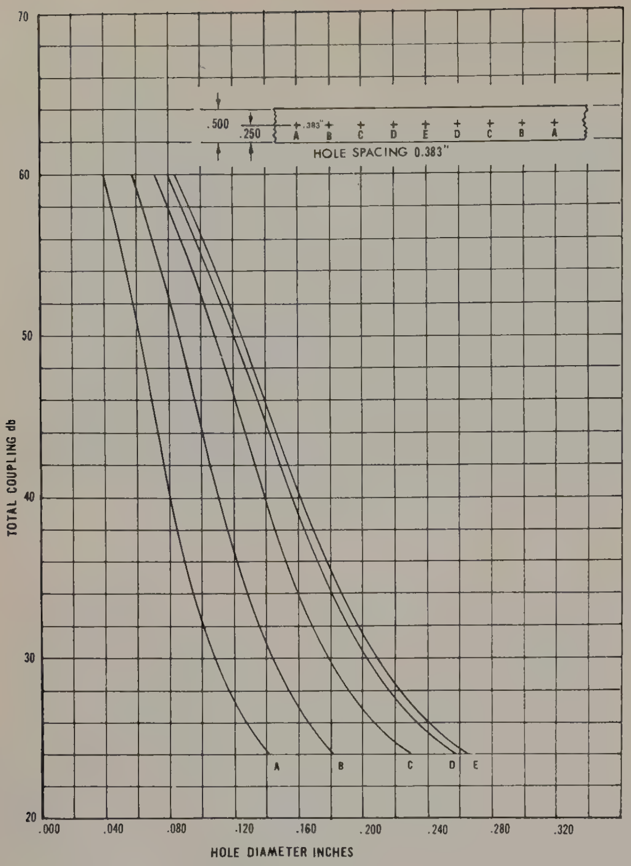

Figure 7 — Design of X-band narrow wall coupler.

ADDITIONAL COUPLER DESIGNS

Loosely Coupled Narrow-wall Couplers

Narrow-wall couplers are very useful in sampling high power. These couplers consist of a series of holes spaced one-quarter guide wavelength apart along the centerline of the narrow wall. The design curves for the total coupling of X-band narrow-wall couplers is presented in Figure 7. No computations are required to design an X-band narrow-wall coupler. Curves A, B, C, D and E correspond to holes in the side wall. For example, a 40-db narrow-wall coupler would have nine holes. Holes A are .081-inch diameter; holes B are .110-inch diameter; holes C are .139-inch diameter; holes D are .157-inch diameter and the center hole, E, is .160-inch diameter. This coupler is a high-directivity coupler, therefore, a very low VSWR termination should be used in the isolated arm.

Tightly Coupled Narrow-wall S-band Coupler

Coupling values between 4 and 26 db can be designed using the curve shown in Figure 8. These couplers have two rows of holes located on lines halfway between the centerline and the top and bottom wall. The centerline of the first hole in the top row is offset by one-quarter guide wavelength from the centerline of the first hole in the bottom row. Each hole is 3/8-inch high and is $l+3/8$-inch long. The holes are milled out with a 3/8-inch end mill.

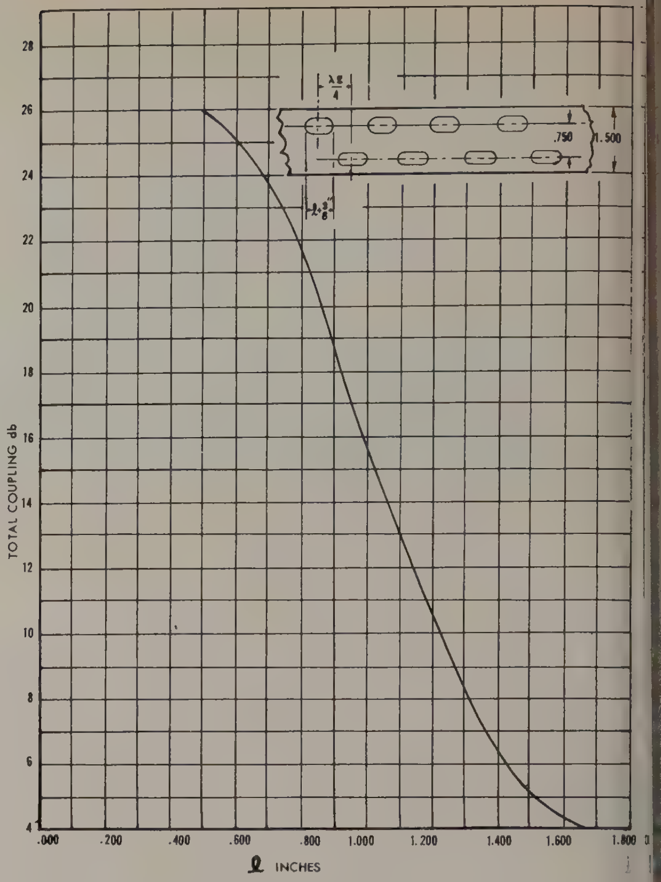

Figure 8 — S-band narrow wall coupler. Four holes per row. All holes .375 inches high.

Conclusions

The size of directional couplers can be reduced by using fewer holes and increasing the diameter of the remaining holes. The removal of one hole in each array reduces the overall length by a quarter wavelength. The use of electroformed or cast bends also allows for a considerable size reduction and an improvement in dimensional tolerances. Also, by using miniature terminations in the isolated arm, more space is saved. Through the use of these space-saving techniques, the length of couplers has been reduced by approximately 65 per cent in comparison to presently available couplers. These techniques are applicable in any waveguide band.

With the design curves presented here, it is possible for the engineer to obtain any value of directional coupler that is desired.

This work was carried out under Signal Corps Contract DA 36-039 SC-85402 and DA 36-039 SC-87475.

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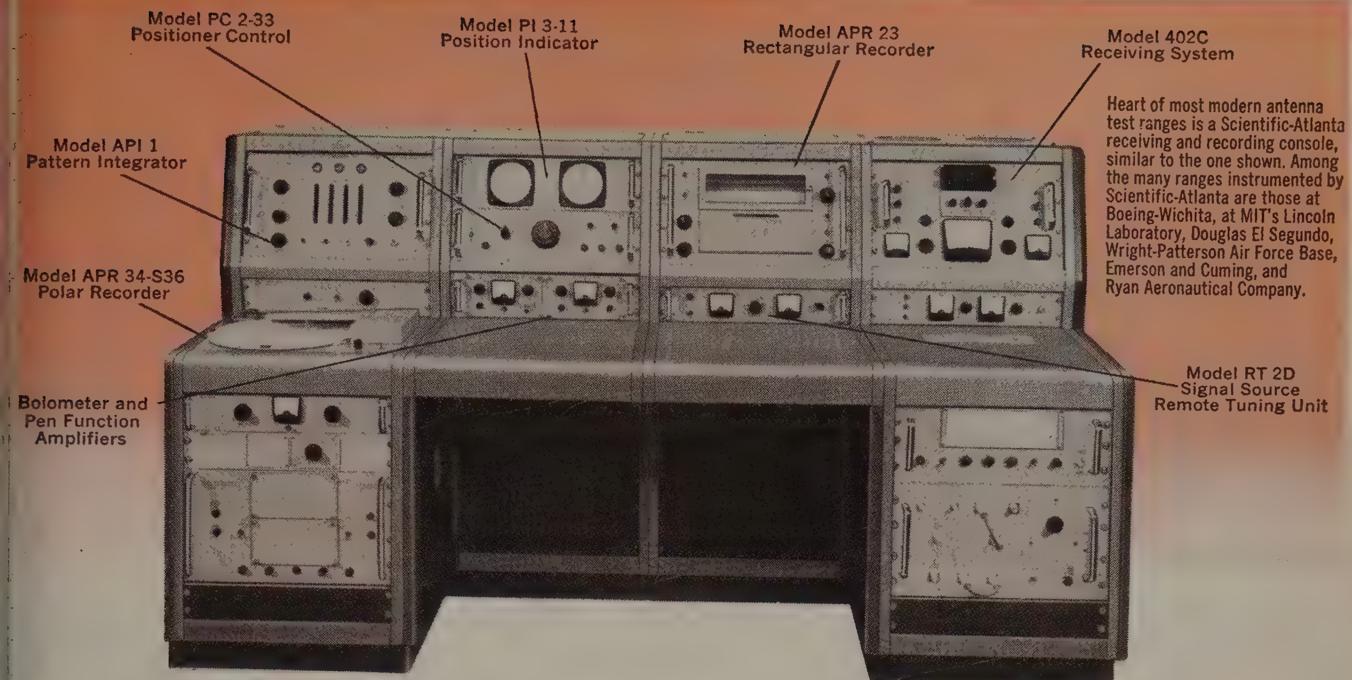
2. Hensperger, Edward, "The Design of Multihole Coupling Arrays", *microwave journal* Vol. 2, No. 8, August 1959, 38-42.



Heart of most modern antenna test ranges is a Scientific-Atlanta receiving and recording console, similar to the one shown. Among the many ranges instrumented by Scientific-Atlanta are those at Boeing-Wichita, at MIT's Lincoln Laboratory, Douglas El Segundo, Wright-Patterson Air Force Base, Emerson and Cuming, and Ryan Aeronautical Company.

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Features include servo control with tachometer feedback, a noise compression circuit, an electric pen lift, and a three-axis synchro input selector. The rectangular recorder has an automatic chart-cycle advance, illuminated chart, three chart scale expansions with forward-reverse, and chart position control. The polar recorder features a recording diameter of 7 and 13 inches, a turntable slip-clutch, pen standby and load switch, calibrated turntable, and chart center light.

WIDE RANGE RECEIVING SYSTEM—A double conversion superheterodyne receiver, the Scientific-Atlanta Series 402 covers the range from below 30 mc to more than 100 kmc.

Features include a sensitive AFC circuit which prevents the receiver from losing track during transmitter frequency drift. One coaxial cable eliminates costly lossy wave guides and rotary joints. Antennas can be located up to 75 feet away with negligible loss in sensitivity, or more than 200 feet away with low loss cables. Reception of cw signals from simple sources eliminates need for precise modulation.

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Modification P-4 adds 20 db to the normal 40 db dynamic range providing 1 db linearity over a full 60 db dynamic range. Modification Z adds a precision IF attenuator and VTVM appreciably reducing the number of components and instruments required for level, gain, and isolation measurements.

ANTENNA POSITIONERS—Scientific-Atlanta offers medium and heavy duty azimuth and multi-axis antenna positioners. Standard models range from the PMA-3 medium duty azimuth positioner designed for a maximum vertical load of 200 pounds with a maximum bending moment of 200 foot pounds to the large PAEA 29 H azimuth over elevation over azimuth for vertical loads of 15 tons and a bending moment of 30,000 foot pounds.

Features include use of Kaydon four-point contact bearings which minimize sliding friction, weather and dust proof design, and 1:1 and 36:1 speed synchros for each axis of rotation. Slip rings, rotary joints, and limit switches can be provided in any axis of any positioner.

MICROWAVE COMPONENTS—Scientific-Atlanta also offers a coaxial rotary joint for dc to 16 kmc at speeds up to 2000 rpm, a series of coax to waveguide adaptors, standard gain horns, crystal mixers, transmitting antennas, polarization positioners, model range towers and recorder supplies.

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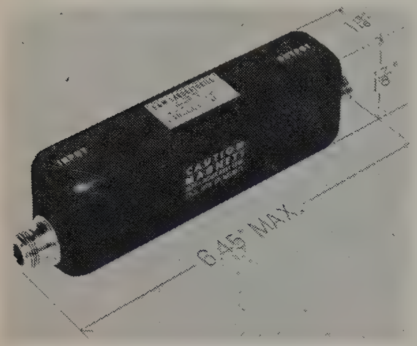
New Products

F&M OFFERS MINIATURE L-BAND COAXIAL ISOLATOR



Miniature L-band Coaxial Isolators with improved electrical characteristics are now available from E&M Laboratories, Van Nuys, Cal.

The units, 6.45 inches long and less than two pounds in weight, have been reduced to one-half the previous volume and weight. Standard units covering the frequency range of 1.0 - 2.0 kMc/s have a 10:1 isolation/insertion loss ratio and a VSWR of 1.15 maximum. Narrower band units are also available with much higher isolation/insertion loss ratios.

Standard units in single quantities are priced at $325 and have a three week delivery.

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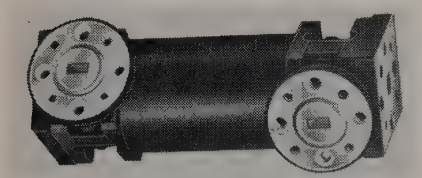
FERROTEC ANNOUNCES LINE OF V-BAND FERRITE MILLIMETER COMPONENTS



Ferrotec, Inc., Newton, Mass., has announced a new line of ferrite microwave components for use at Ku-, K- Ka-and V-bands.

Model R-227LS is used to time share two antennas with a common transmitter and receiver. High isolation and a constant VSWR are maintained while switching between antennas.

The unit is a 2.5 inch long, four-port, V-band fast switch for use over a frequency range of three per cent at 70 kMc. The switch attains greater than 20 db isolation, 1 db maximum insertion loss and a VSWR of less than 1.30. Switching times of less than 1 microsecond are attained with moderate drive power. A permanent magnet can be provided to allow the device to be employed as a four-port circulator. There is also available in this range a narrow band (three per cent) Wye junction circulator and isolator.

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LFE DESIGNS ULTRA-STABLE MICROWAVE OSCILLATOR

The Instrument Division of Laboratory For Electronics, Inc., Boston, Mass., has introduced a new ultra-stable microwave oscillator, model 814-L-9, for applications in missile and satellite telemetry.

The instrument is designed to exceed requirements recently established by the Range Commanders' Conference on Telemetry Standards which call for frequency stability in the 2200 - 2300 Mc telemetry band of 0.005 per cent for transmitters and 0.001 per cent for receivers.

The 814-L-9 brackets the telemetry band with a tunable frequency range of 2000 - 2500 Mc/s, and has a short-term stability of five parts in 10^8 and long-term stability of one part in 10^6. The dial is calibrated in one Mc/s divisions with an accuracy of 0.1 per cent absolute.

An internal one kc/s sine-wave oscillator permits amplitude modulation of up to 15 per cent. Modulation greater than 15 per cent can be obtained with an external gyrator or similar device. Total deviation of up to 0.01 per cent of frequency setting is permitted.

Power requirements are: 105 - 125 VAC, 200 - 250 VAC, 50 - 400 cps, 200 watts. A blower is normally furnished for 50 - 60 cps operations. Power output (nominal) is 100 mw with a Type N connector.

The 814-L-9 measures 21 1/6 inches wide by 14 9/16 inches high by 18 inches deep for rack mounting.

Priced at $4,950 (FOB Boston, Mass.), the 814-L-9 is scheduled for delivery within 90 - 120 days of order.

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MICROWAVE GARNET MANUFACTURED

A low-loss microwave garnet has been announced by Richard Bell, sales manager of Microwave Chemicals Laboratory, Inc., New York, N. Y. This material, MCL-300, is primarily intended for use in UHF and L-band regions. Typical applications include three-port or four-port low-loss circulators, either in full waveguide or coaxial.

Very low noise and fast switching are also possible with the new Microwave MCL-300 Garnet when in combinations with masers where low noise is highly desirable. This material is available in bars, cylinders and discs of various sizes and has a Curie temperature of 125°C.

The following specifications have been measured on this material saturation magnetization — 300 gauss/cc; linewidth ($\triangle H$) at S Band — 55 oersteds; dielectric loss tangent at 20 Mc/s — 1.6 x 10^{-3}; dielectric constant $E'E_0$ at 20 Mc/s — 11.7; density — 5.08 gm/cc; g value — 2.05.

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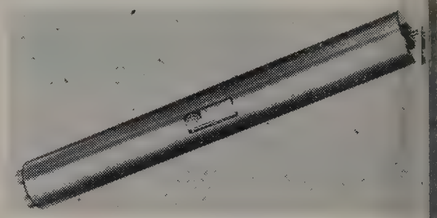
LOW-NOISE PPM TWT DEVELOPED BY HUGGINS

A periodic permanent magnet focused low-noise traveling-wave tube, operating in S-band, has been developed by Huggins Laboratories, Inc., Sunnyvale, Cal.

The tube, designated HA-54, when operated from 2.4-3.4 kMc, has a noise figure of 13 db maximum, small-signal gain of 25 db minimum, and saturation power output of five dbm minimum.

Operated over the 2.4-3.0 kMc range the HA-54 attains a maximum noise figure of 11 db, minimum small-signal gain of 27 db, and minimum saturation power output of seven dbm.

The tube requires no focusing solenoid or solenoid power supply, is rugged, compact, and lightweight, measures 18 inches long with 2 inch OD, and weighs 3 1/2 pounds.



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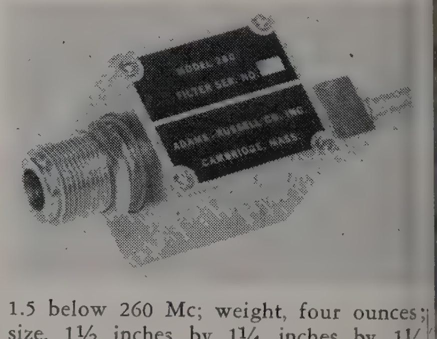
UHF HARMONIC FILTER DEVELOPED BY ADAMS-RUSSELL

An UHF Harmonic Filter, model 280, suitable for missile and airborne applications, has ben developed by Adams-Russell Co., Inc., Cambridge, Mass.

Elimination of harmonic radiation from 215 - 260 Mc telemetry transmitters is its primary use. The model is designed to serve as the RF output fitting for a pressure-tight transmitter.

Characteristics are: pass band, 0 - 320 Mc; insertion loss, less than 0.5 db below 260 Mc, 50 db above 450 Mc; VSWR 1.5 below 260 Mc; weight, four ounces; size, 1½ inches by 1¼ inches by 1¼ inches; and power, 50 watts.



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ALFRED ELECTRONICS

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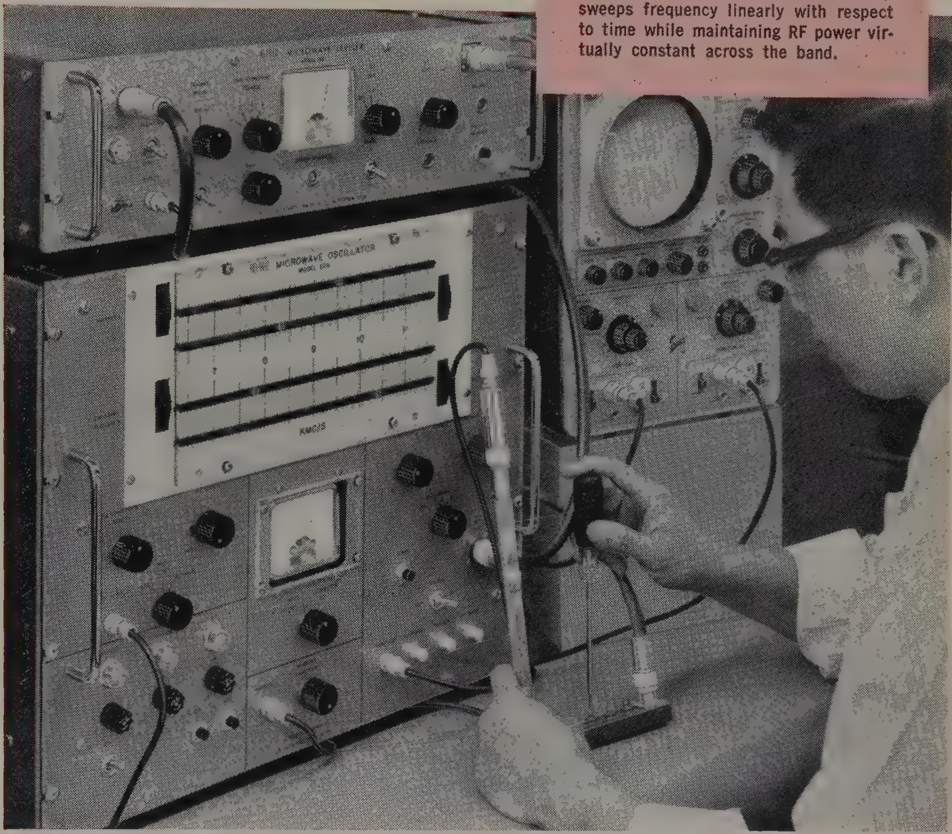

Testing insertion characteristics of X-band filter with Alfred Swept Generator which consists of Alfred Microwave Oscillator and Alfred Microwave Leveler. This combination electronically sweeps frequency linearly with respect to time while maintaining RF power virtually constant across the band.

MICROWAVE SWEEP GENERATORS

Still the industry's most advanced oscillators. Series 620 single band models and Model 605 use convenient plug-in generator heads covering 1-26.5 kmc. Models 6001B-6004C provide 1 watt output, electronically swept or stable single frequency, 1-12 kmc.

Features include built-in leveler and narrow band symmetrical sweep, adjustable frequency markers, and Quick Look readout. Drift, less than ±.02% per hour; residual FM, less than ±.0025% peak.

These units save valuable engineering time by providing constant RF power input to microwave tubes and other components under test. With constant input, variations in output indicate directly component transfer characteristics. Microwave properties are examined over continuous spectrum, assuring accuracy during broad or narrow band testing. Prices: Model 620 series, $2,890-3,340; Model 605, $1,750; Generator Heads, $1,500-1,990; Model 6001B-6004C, $7,250-8,690.

MICROWAVE LEVELERS

Ideal instruments for maintaining constant power output (±1 db) with long term stability. CW or square wave modulation. Fast response, very high gain assure flat RF output from BWO's. Also available: Model 700 leveler amplifier, which may be used with external RF components. Prices: Microwave Levelers, $875-990; Model 700, $575.

MICROWAVE AMPLIFIERS

Alfred manufactures microwave amplifiers for virtually every requirement — general purpose, medium power, high gain, and low to medium noise figure. All models feature low spurious modulation and stable operation. General purpose amplifiers provide 30 db gain and 10 mw power output with 25 db noise figure. Medium power models offer power up to 10 watts. High power amplifiers provide up to 1 Kw pulse power. Low noise amplifiers provide noise figure from 6 to 15 db at frequencies from .5 to 12 kmc.

In addition to standard amplifiers, Alfred offers periodic or permanent magnet focused amplifiers where light weight and low input power is required as well as amplifiers designed specifically for phase modulation. Prices: General purpose amplifiers, $1,490-1,690; Medium power amplifiers, $1,550-3,590; Low noise amplifiers, $3,150-4,990.

POWER SUPPLIES

Alfred furnishes four basic types of power supplies. Model 250 Traveling Wave Tube Supply operates low and moderate power traveling wave amplifier and oscillator tubes. This instrument provides all normal sources — helix, collector, four separate anodes, grid, heater, solenoid and blower — from one compact unit.

Microwave Power Supplies Model 252, with the unregulated and regulated solenoid supplies Model 253 and 254, operate all presently known low and medium noise figure TW tubes. Model 252 furnishes electrode and heater power for permanent magnet focused TW tubes. Electromagnet focused TW tubes require in addition either Model 253 or 254 solenoid supply. Alfred's Sweeping Power Supplies serve as general purpose sources for either electronically swept or fixed frequency operation of voltage tuned magnetrons, BWO's and similar microwave tubes. Alfred's floating high voltage supplies provide extremely stable and highly regulated DC voltages, featuring wide voltage and current ranges, very small ripple and accurate voltage adjustment. Prices: Model 250, $1,990; Models 252, $890; 253, $300; 254, $400; Sweeping Power Supplies, $1,650-1,690; High Voltage Supplies, $690-1,090.

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(*Continued from page 94*)

LIGHTWEIGHT ALL-METAL REFLECTORS AVAILABLE

A new line of all-metal lightweight reflecting optics for application in infrared detectors, low resolution image forming devices, solar energy collectors and radar antennas is being marketed by Electro-Optical Systems, Inc., Pasadena, Cal.

Reflectors are available in sizes from a fraction of an inch to over five feet in diameter, with weights ranging from 0.4 to 1.5 pounds/square foot. They feature extreme durability and high optical quality. Reflectors have no limitations in aperture ratio and presently extend from f/8 to f/0.4 in focal length.

Configurations of these lightweight optics include spherical, parabolic, elliptical, and hyperbolic in both on-axis and off-axis geometries. Reflecting elements with mean angular deviations of less than one minute of arc (0.3 milliradians) can be provided.

Structure is 100 per cent metal with integrally formed supports and attachments. Reflective coatings are available in aluminum, silver, and gold. Silicon monoxide overcoatings can be provided.

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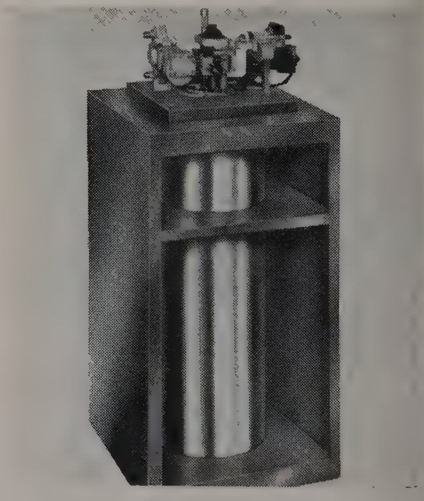
PORTABLE MASERS AT X-BAND DEVELOPED

Microwave Technology Inc., Waltham, Mass., has announced the development of portable masers at X-band. The units feature a permanent magnet inside a metal dewar resulting in an amplifier weight of approximately 50 lbs.

At a gain of 20 db, the bandwidth is 10 Mc. The unit is gain stable and the amplifier can be tuned over a 150 Mc bandwidth. Noise temperature is under 50°K.



Approximately 24 hours operation is possible with one filling of liquid helium.

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RF POWER MONITORING DIODE CONSTRUCTED

A new rf power monitoring diode (MA-462) for measurement applications in the X-Band region is available from Microwave Associates, Inc., Burlington, Mass.

Anticipated uses for the MA-462 include measurement of microwave power or voltage, impedance, power ratios and frequency, and a wide variety of applications where simplicity and low cost are essential. In such applications, the diodes are used as a low-cost substitute for bolometers.

The MA-462 is housed in a hermetically sealed reversible polarity cartridge and is guaranteed for operation to 150°C. It meets the environmental conditions of MIL-S-19500B.

The MA-462 replaces the MA-425 and the fixed base type MA-424 in high reliability circuits. A rectified output voltage with controlled variation is provided for input power levels between 10 microwatts and 10 milliwatts CW.

The diode may be used with transmitters for monitoring rf oscillators, or for controlling other circuit functions by means of the rectified dc voltage developed across the diode.

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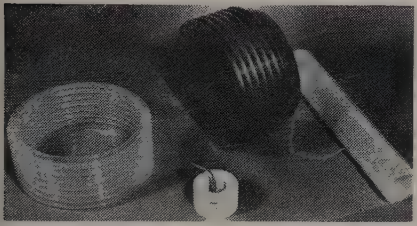
ELECTRO-TEC OFFERS LINE OF TEFLON CLAD SLIP RINGS



Introduction of a new Teflon line of slip ring assemblies has been announced by Electro-Tec Corp., South Hackensack, N. J.

The Teflon clad slip rings are capable of handling high voltages without characteristic arcing damage even under operating conditions of extreme humidity. At the same time they maintain very high resistance between circuits and offer extreme inertness throughout temperature range of −200°C to +200°C.

The new line is the result of mixing Teflon and epoxy and using it in slip ring production, offering the inherent electrical and chemical advantages of Teflon with the excellent structural characteristics of epoxy materials.

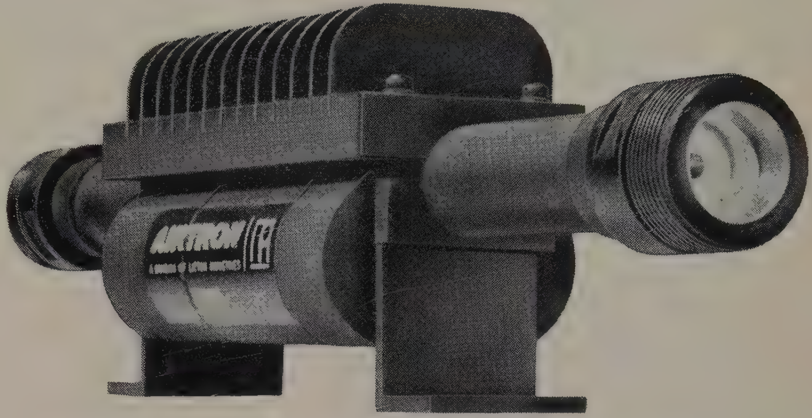
Electrically pre-tested Teflon sheets are used in a three step forming operation. The final slip ring assembly consists of a molded Teflon shell filled with epoxy.

Circle Reader Service Card 110

—*mwj*—

(*Continued on page 98*)

ONE WAY



STREET

This particular Airtron ferrite isolator is a high-power broad-band coaxial unit. We make these and many other one-way streets for errant energy in a very broad variety of mechanical and electrical characteristics: many of them are from stock. Because we tailor and produce our own ferrite materials in our Advanced Devices Laboratory to meet special requirements, we can custom build for you with nominal lead time.

Here are condensed specifications for the isolator pictured:

Isolation	15db minimum.
Insertion loss	0.8db maximum over 20% bandwidth. (Can also be made to cover 50% bandwidth for ECM or CCM applications).
Power handling capacity	400 watts *average*. CW(Air cooled).
Input VSWR	1.12 maximum.
Frequency	S-Band or L-Band.
Material	Aluminum.
Line size	⅞-inch coax.
Connectors	L/T both ends, gender optional.
Length overall	13.85 inches nominal, S-Band. 16.84 inches nominal, L-Band.
Weight	3.50 lb. maximum, (S-Band unit).
Ambient Temperature	−20° to 100°C, (L-Band unit).

We invite your inquiry for additional information on Airtron's comprehensive line of ferrite isolators.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N. J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N. J.

Circle Reader Service Card 52

For Research at Minus 459°F

hofman

Liquid Helium Research Dewars

Hofman stainless steel dewars are the ultimate for low-temperature research. Samples under study can be retained at liquid helium temperature for as long as 10 days without replacing the expensive liquid. Hofman dewars provide a lifetime of strength, efficiency and economy. They are widely used for solid state maser studies, low-temperature chemistry, microwave spectrometry, superconductivity studies, free radical research, metallurgical research and nuclear research.

SEND FOR **NEW CATALOG**

Also: Containers for Liquid Oxygen, Nitrogen, Hydrogen and Helium. Accessory Low Temperature Equipment.

hofman

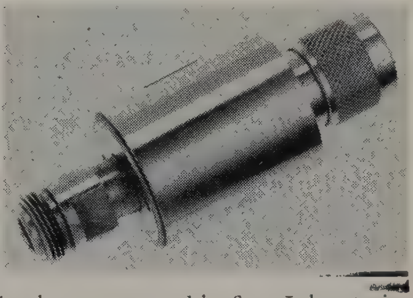
LABORATORIES, INC.
5 Evans Terminal, Hillside, N. J.

Representatives in principal industrial and military centers.

(*Continued from page 97*)

COAXIAL ROTARY JOINT AVAILABLE FROM SAGE

A coaxial rotary joint, designed to meet stringent torque and noise requirements, has been announced by Sage Laboratories, Inc., Natick, Mass.



The model 320 is especially suited to antenna-receiver and servo-drive applications from 800 - 12,000 Mc. Line continuity is maintained by means of capacitive coupling of the outer conductors and the use of precious metal contacting-junction inner conductors.

The rotary joint is equipped with type N connectors, but models can be supplied with any connector that is compatible with the basic 50 ohm line. The use of alternative connectors permits the optimizing of the basic unit over any given 20 per cent of the frequency range. The effective range is determined by the electrical characteristics of the alternative connector.

Maximum VSWR is 1.1 at 800 - 6000 Mc, 1.2 at 6000 - 8000 Mc, and 1.3 at 8000 - 12,000 Mc. Maximum insertion loss is 0.3 db at 800 - 1200 Mc, 0.2 db at 1200 - 3000 Mc, and 0.1 db at 3000 - 12,000 Mc. Torque is 1.0 oz/in maximum, continuous duty rotational speed is 1000 rpm, and WOW is negligible.

Unit price is $125; delivery in small quantity is from stock.

Circle Reader Service Card 111

—*mwj*—

10:1 PASSIVE ATTENUATOR PROBE PRODUCED BY DU MONT-FAIRCHILD

A new probe, type 4290, usable with nearly all commercial oscilloscopes — high or low frequency — has been produced by the Allen B. Du Mont Laboratories, Clifton, N. J., Division of Fairchild Camera and Instrument Corp. Extremely rugged and attractively styled, the unit is a 10:1 fixed ratio attenuator probe usable with instruments having bandwidths of dc to more than 60 Mc.

The 4290 probe will not degrade the bandwidth of a 35 Mc scope more than ±1 db. To compensate for changes in capacitance from one unit to another, the probe is equipped with an adjustable capacitor which is varied simply with an external mechanical adjusting sleeve. No adjustment tools are required. With this feature, a one megohm input resistor and an input capacity range of 20 - 55 picofarad may be accommodated. The 4290 is designed to handle input voltages of 1200 volts (±600 volts), making it possible to test signals at amplitudes exceeding the direct inputs of most oscilloscopes.

Included with the probe package is a set of long and short test prods, spade lugs, banana jackets, phone tips, alligator clips, a "stretch wire" ground clip, and an adapter fitting to accommodate the sundry probe tips.

The probe body is approximately 8 1/2 inches long; with cable and BNC termination connector, total length is 48 inches. Price of the 4290 probe is $25 and delivery is from stock.

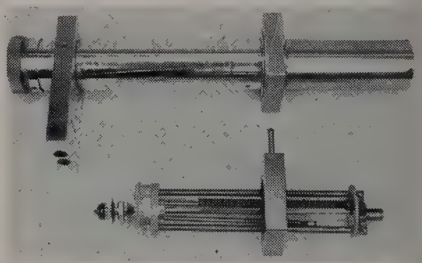
Circle Reader Service Card 112

—*mwj*—

OSCILLATOR CAVITY FEATURES ±2 Mc CALIBRATION ACCURACY

A microwave oscillator cavity developed by Frequency Standards, Asbury Park, N. J. features a ±2 Mc calibration accuracy and 0.1 per cent resetability using a direct reading frequency tuning mechanism. The cavity is designed to withstand conditions of extreme shock and incorporates a ruggedized anti-backlash tuning mechanism.

Operating frequency is from 400 - 1000 Mc. When used with 2C36 or similar UHF Triodes, 10 mw of power into a 50 ohm load is achieved. The oscillator also includes a waveguide-beyond-cutoff type attenuator permitting directly calibrated power output from —120 - 0 dbm. Power output is monitored by means of bead and disc thermistors in a a thermal-compensated bridge.



Price is approximately $250 to $350 each in production quantities, and delivery is 90 to 120 days.

Circle Reader Service Card 113

—*mwj*—

(*Continued on page 100*)

Hughes TWT capability offers you

New solutions for tube and systems problems

A continuing program of applied research by Hughes has resulted in the development of outstanding operating features such as those illustrated in the accompanying cutaway of a high-powered TWT.

When *you* have a requirement for an advanced microwave tube—CW or pulsed—consider TWT's, and Hughes. Perhaps the solution to your problem is already in development, or *production*, at Hughes.

For a more complete rundown on what Hughes can offer you, contact your nearest District Office today, or write for your copy of the Hughes short form catalogue.

NORTHEASTERN 4 Federal Street, Woburn, Mass. WEIls 3-4824

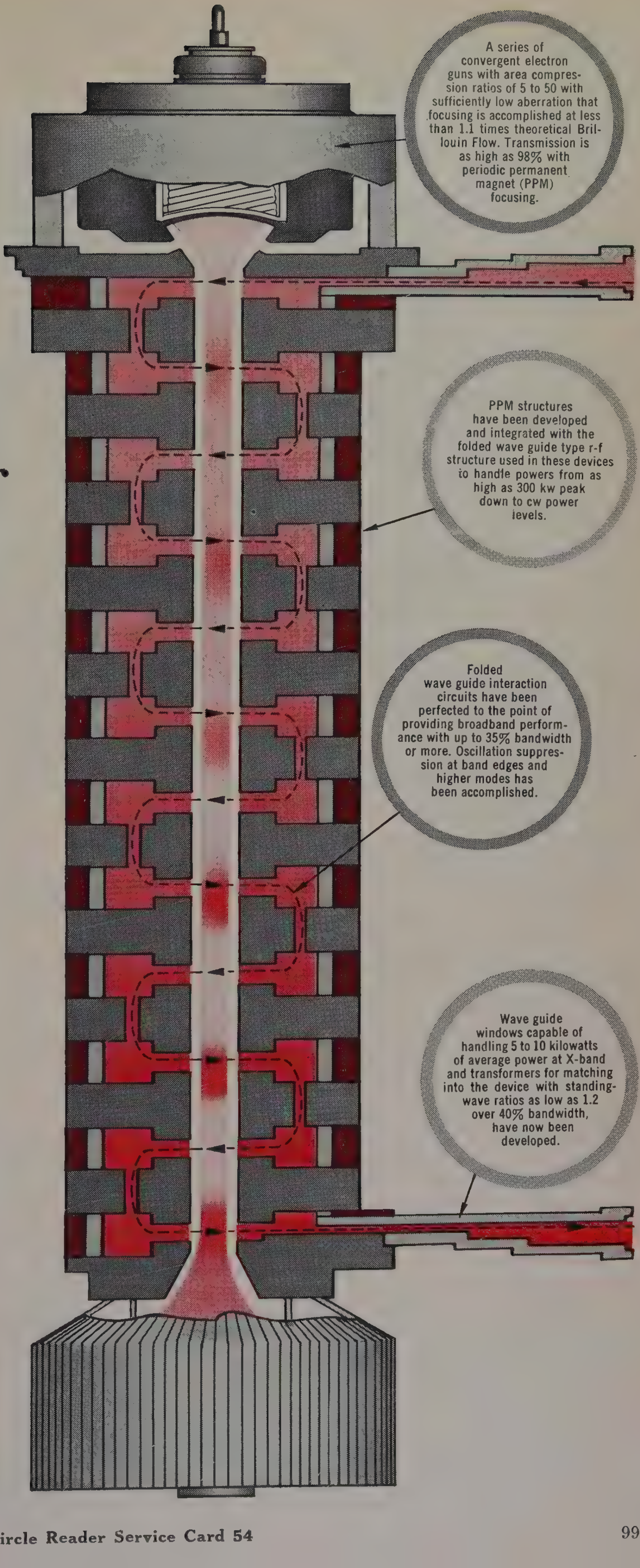
EASTERN 2000 "K" Street, N.W., Washington 6, D. C. FEderal 7-6760
13 Lloyd Avenue, West Long Branch, N. J. CApital 2-1111

WESTERN 11105 South La Cienega Blvd., Los Angeles 45, Calif. SPring 6-1515

CREATING A NEW WORLD WITH ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY
MICROWAVE TUBE DIVISION



A series of convergent electron guns with area compression ratios of 5 to 50 with sufficiently low aberration that focusing is accomplished at less than 1.1 times theoretical Brillouin Flow. Transmission is as high as 98% with periodic permanent magnet (PPM) focusing.

PPM structures have been developed and integrated with the folded wave guide type r-f structure used in these devices to handle powers from as high as 300 kw peak down to cw power levels.

Folded wave guide interaction circuits have been perfected to the point of providing broadband performance with up to 35% bandwidth or more. Oscillation suppression at band edges and higher modes has been accomplished.

Wave guide windows capable of handling 5 to 10 kilowatts of average power at X-band and transformers for matching into the device with standing-wave ratios as low as 1.2 over 40% bandwidth, have now been developed.

Circle Reader Service Card 54

Electro-Hydraulic Antenna Drives Provide the "Performance" Answer

Continuous operation of our advanced radar warning fence imposes tremendous demands on the servomechanisms controlling antenna sweep and tracking.

Compact power packages utilizing Pegasus Servo-Valves, Actuators and Amplifiers have built an outstanding reputation for precision and dependability in antenna installations, both airborne and ground-based.

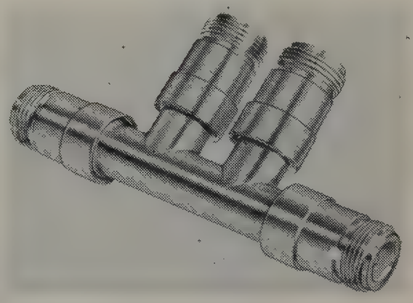
The combination of a high performance Servo-Valve and motor with an integral feedback tachometer and transistorized Servo Amplifier provides accurate tracking and reliable antenna sweeping.

Let us help you with your antenna drive problems. Call or write:

PEGASUS
LABORATORIES, INC.
DESIGN AND MANUFACTURE OF
ELECTRO-HYDRAULIC SERVOMECHANISMS
3500 Eleven Mile Road, Berkley, Mich.
telephone: Lincoln 7-8700
cable address "Pegasus" Berkley

(*Continued from page 98*)

MINIATURIZED DIRECTIONAL COUPLERS AVAILABLE FROM MICROLAB



Microlab, Livingston, N. J., has announced a new series of coaxial directional couplers designed for use up to 4000 Mc and featuring flat coupling, high directivity, and low VSWR.

Two models are available to satisfy a wide range of requirements. The CA model has both ends of the auxiliary line available for bi-directional signal sampling. The CB series has one end permanently terminated to assure optimum directivity.

The directional couplers are constructed in a lightweight, miniaturized housing, providing exceptionally rugged, waterproof units to satisfy most MIL environmental requirements. Couplings of 3, 6, 10, and 20 db are available in octave ranges from 200 - 4000 Mc with a choice of N, C, BNC, or TNC connectors.

A price range of $100 to $150 has been established for these couplers which are available for immediate delivery from stock.

Circle Reader Service Card 114

—mwj—

WEINSCHEL EXTENDS FREQUENCY RANGE OF MODEL 50 ATTENUATORS

The Weinschel Engineering Co., Kensington, Md., has recently redesigned its line of model 50 precision coaxial attenuators, adding several more features.

The model attenuator is available in values of one db through 10 db in one db steps and 10 db through 80 db in 10 db steps. As a result of the redesign, the frequency range which was formerly from dc to one kMc has been extended to cover frequencies from dc to three kMc. The 60, 70, and 80 db values were not made available at an earlier date as catalog items due to prior difficulties in production testing such high attenuation values.

Each of the model 50 attenuators will be accompanied by a certificate of calibration showing the insertion loss test data at dc, 1000, 2000, and 3000 Mc with a 50-ohm termination. The accuracy of this test data is explicitly stated on the certificate and is fully guaranteed.

The type 'N' connectors on the model 50 will be made of stainless steel for maximum life with minimum wear. A further feature of these connectors is the extremely close tolerance used for the critical dimension of the inner contact depth, ±0.005 inch, which is closer than NBS requirements for testing.

Circle Reader Service Card 115

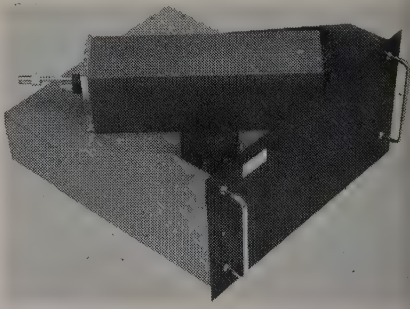
—mwj—

ULTRA LOW-NOISE PACKAGED AMPLIFIERS DESIGNED BY WATKINS-JOHNSON

Watkins-Johnson Co., Palo Alto, Cal., has announced the commercial availability of its WJ-111 and WJ-112 ultra low-noise packaged wideband amplifiers.

The units have been designed for reliable unattended field operation and cover the 2 - 4 kMc and 1 - 2 kMc regions, respectively, with typical noise figures of 4.3 and 4.0 db in S- and L-bands and guaranteed maximum values of 5.5 and 5.0 db respectively. For lower noise figure over restricted parts of the band, amplifiers incorporating special tubes can be supplied. All necessary voltages are supplied by the WJ-180 power supply.

The units are furnished with relay rack panels and cabinets, but can be ordered without cabinets by specifying WJ-111R and WJ-112R. RF input and output connections are made directly to the tube through the rear of the cabinet. Front-panel rf jacks can be furnished on special order.



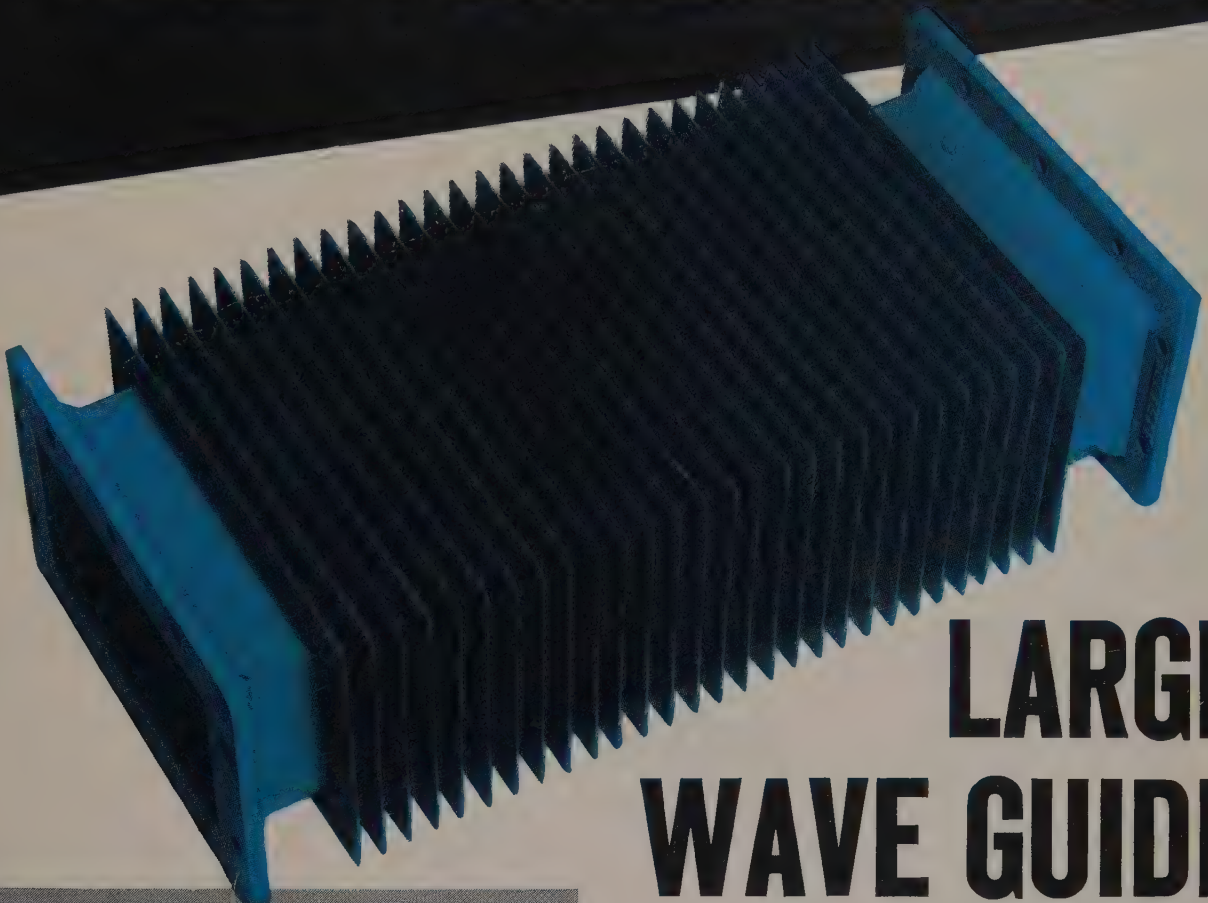
The WJ-111 is priced at $3650 and the WJ-112 at $4200, with delivery from four to six weeks.

Circle Reader Service Card 116

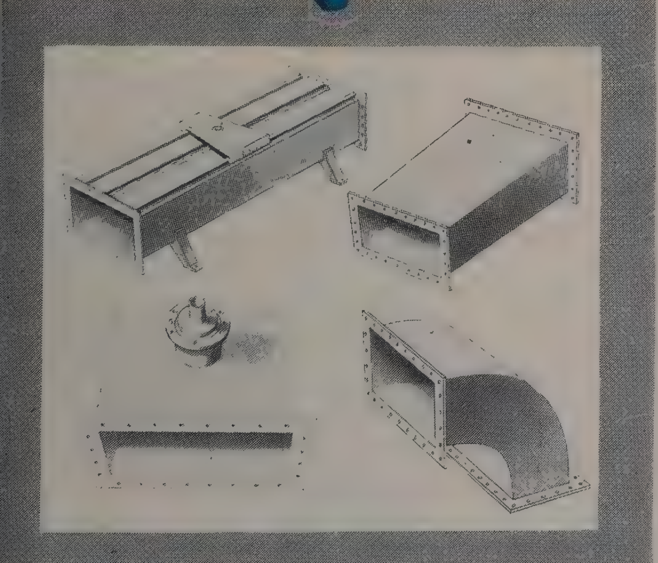
—mwj—

(*Continued on page 102*)

HIGH PERFORMANCE



LARGE WAVE GUIDE



NOW, the advanced design techniques of Applied Microwave Electronics and the engineering competence and manufacturing know-how of Washington Aluminum Company are combined to provide industry with the most comprehensive line of large waveguide components. This successful combination of creative capability and custom craftsmanship means high quality, yet economical, production of: Straight Sections (VSWR 1.02), Bends (VSWR 1.03), Coax to Waveguide Transitions, Directional Couplers, Fixed Terminations, Sliding Terminations, Sliding Short Circuits, Taper Sections, Slotted Lines and Finned Waveguide.

This added to our present proven antenna capabilities assures that we can accept systems responsibility for integration of all passive microwave equipment.

DIRECT INQUIRIES TO:
APPLIED MICROWAVE ELECTRONICS, INC.
6707 WHITESTONE ROAD
BALTIMORE 7, MARYLAND

APPLIED MICROWAVE ELECTRONICS AND

WASHINGTON ALUMINUM CO., Inc.

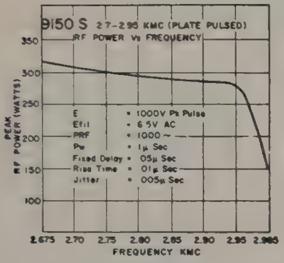
Circle Reader Service Card 56

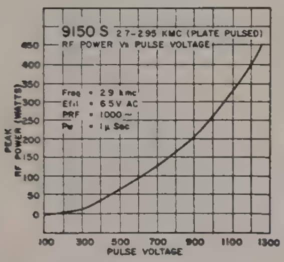
WHERE OVERALL
POWER EFFICIENCY
AND SPACE SAVING
A MUST...

THE NEW RUGGED
TRAK S-BAND
OSCILLATOR

Mechanically rugged enough for use in environments requiring a very high accelerative force, such as in proximity fuse work!

Performance Curves:





SPECIFICATIONS ARE:

Frequency: 2.7-2.95 KMc.
Power Output: 200 Watts peak (test conditions—1 microsec. PW, 1000 PRF).
Power Input: Epp = 1 KV Ipp = 1.0 amp
Efil = 6.5 Ifil = 240 ma
Duty Cycle: .0025 maximum.
Output Pulse Rise Time: 15 millimicrosec.
Output Pulse Jitter: 5 millimicrosec.
Fixed Delay: 50 millimicrosec.
Vibration: 15 G from 50-2000 cps, 3 axes, less than ±1 Mc FM.
Shock: 100 G, 6ms, 3 axes, less than 250 Kc FM.
Temperature Stability: 2 Mc maximum drift from 0°C. to 90°C.
Mounting: Engineered to customer specifications.

Miniature Microwave Energy Sources, engineered to your specifications.

Write today for new Catalog 61B, full of oscillators for CW, grid pulse and plate pulse service.

TRAK Microwave

TRAK MICROWAVE
CORPORATION
5006 N. Coolidge Avenue
Tampa 3, Florida
REdwood 6-6422

New Products

(Continued from page 100)

DISPLAY STORAGE TUBE CONSTRUCTED BY WESTINGHOUSE

A five inch electrostatically focused and deflected writing gun tube, type WL 7682, is available from the Westinghouse Electric Corp., Electronic Tube Division, Elmira, N. Y. The new display storage tube incorporates one writing gun and one flood gun.

The flood gun has a simplified electrostatic lens structure which requires adjustment of only one collimation voltage for optimized tube operation. This saves time and money in system setup procedures on the production line and in the field.

The tube is designed to withstand the environmental and reliability requirements of military applications such as airborne fire control, navigational radar, weather radar, and narrow-bandwidth data transmission systems.

A writing speed of 400,000 inches/second and a brightness in excess of 200 foot-lamberts are possible when the tube is operated with a viewing potential of only five kv. Storage time is nominally 30 seconds but can be extended to 30 minutes under certain operating conditions.

The tube has a useful display area of four inches within a maximum outside diameter of 5 1/4 inches, including a potted magnetic shield.

Circle Reader Service Card 117

—*mwj*—

GLASS-BONDED MICA INSULATES AT HIGH FREQUENCIES

Electronic Mechanics, Inc., Clifton, N. J., has completed tests and the assembly of new data which establish two grades of EMI's MYKROY glass-bonded mica as excellent low loss insulators at high frequencies.

The two grades are MYKROY 750 and MYKROY 1100, conforming to MIL-I-10A-L443 and MIL-10A-L442 respectively.

High frequency capacitance coupling devices made of copper and gold plated MYKROY 1100 are now in production at EMI.

MYKROY's machineability, low-loss characteristics, rigidity, and complete freedom from moisture absorption make it particularly useful as a high frequency insulator in place of fluorocarbon type plastics, which soften and distort in moderate ambients and under light loads.

MYKROY glass-bonded mica is virtually the only inorganic insulation which is freely machineable with carbide cutting tools and standard grinding facilities. It is produced by Electronic Mechanics, Inc., in a large glass-bonded mica sheet and is available in sheets, rods and bars for fabrication. EMI also machines, molds and metalizes MYKROY to customer specifications.

Circle Reader Service Card 118

—*mwj*—

STAINLESS PRODUCES GUYED MICROWAVE TOWER

A communication tower that will support two platforms and up to six horn antennas at any height from 25 feet to 500 feet is now in service on a multi-hop TD-2 microwave system in Northwestern Canada, it was announced by Henry J. Guzewicz, vice president of Stainless, Inc., North Wales, Pa.

Designed and fabricated for Alberta Government Telephones by Stainless, Inc., and Walcan, Ltd., Stainless' Canadian subsidiary, the new tower is the first of its kind to be used for horn antenna support.

A guyed structure, it is more adaptable to exact transmission requirements than a self-supporting tower, and is expected to reduce the normal cost of tower material, installation and maintenance for this rigid service by approximately one-third. Sections of the new tower design are stock items at Stainless and at Walcan.

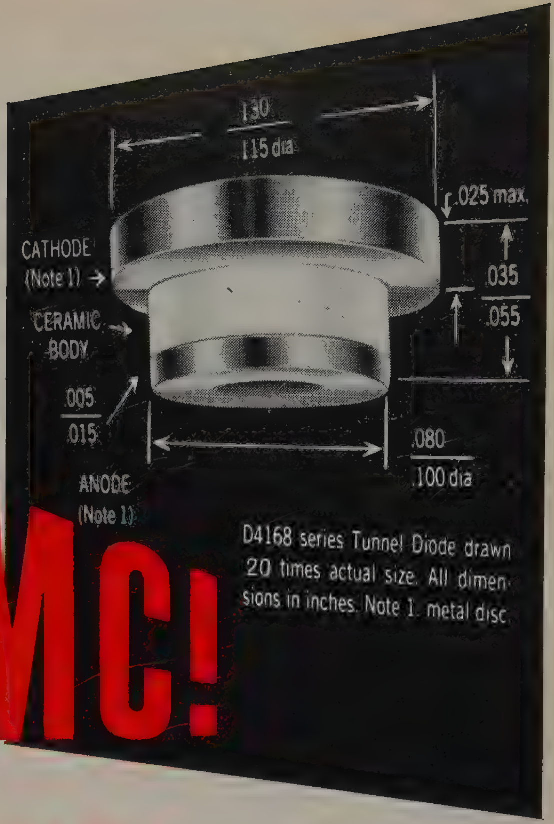
Circle Reader Service Card 119

—*mwj*—

(Continued on page 104)

NEW FROM SYLVANIA

8 & 10 KMC!



D4168 series Tunnel Diode drawn 20 times actual size. All dimensions in inches. Note 1. metal disc

GERMANIUM **TUNNEL** DIODES

SYL-D4168C AND SYL-D4168D NOW READY FOR EVALUATION

FOR SERVICE AS

- oscillators—L-band to X-band
- amplifiers—at C-band
- mixers—better than −90dbm tangential sensitivity at X-band

FOR APPLICATIONS IN

- common carrier equipment
- test equipment
- portable radar
- electronically scanned antenna arrays

Sylvania series D4168 tunnel diodes in the miniature "pill" package featuring performance from 2 KMC to 10 KMC offer you a wide latitude in which to search out practical new applications. These most recent units developed by Sylvania are p-type germanium with typical peak current of 3.5 mA and typical capacitance at valley of 1.0 pf for the 10 KMC units.

Contact your Sylvania Sales Engineer or your Sylvania Franchised Semiconductor Distributor for price and delivery information. Write for technical data: Semiconductor Division, Sylvania Electric Products Inc., Dept. 357, 1100 Main Street, Buffalo 9, N. Y.

ABSOLUTE MAXIMUM RATINGS . . . Storage Temperature −40 to +100°C

ELECTRICAL CHARACTERISTICS AT 25°C

Type	Typ. Peak Current, i_p (mA)	Typ. Capacitance at Valley (pf)	Min. Peak to Valley Current Ratio	Min. Measured Frequency of Osc. (KMC)	Typ. Series Resistance (ohms)
D4168	3.5	3.5	5	2	2
D4168A	3.5	2.5	5	4	4
D4168B	3.5	2.0	5	6	6
D4168C	3.5	1.5	5	8	8
D4168D	3.5	1.0	5	10	10

Negative resistance—70Ω typ.

Series inductance—0.25 mμh typ.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

New Products

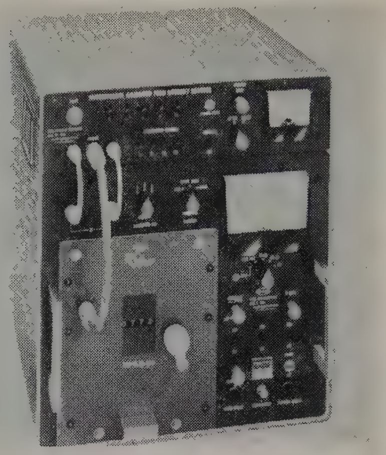
(*Continued from page 102*)

POLARAD DEVELOPS TRANSISTORIZED CALIBRATED FIELD INTENSITY RECEIVER

Polarad Electronics Corp., Long Island City, N. Y., has developed a mobile, transistorized, calibrated field intensity receiver, covering the 1000 - 10,000 Mc frequency range. The entire complement of equipment consists of a basic unit, four interchangeable RF tuning units, an impulse calibrator, five antennas, and a tripod.

Model CFI Microwave Field Intensity Receiving System is designed to perform the tests prescribed by the latest military specifications covering RF leakage and interference in electronic and associated equipment. In addition, such measurements as operational field intensity data, propagation studies, RF signal analysis and general communications can be made under conditions of precise measurement since the equipment has a built-in impulse calibrator which covers the entire frequency range at a high degree of stability. The Model CFI is also capable of accurately determining the shielding effectiveness and harmonic or spurious output of transmitters.

The CFI features a calibrated meter, which indicates average, peak, slide-back peak, and quasi-peak values of RF signals on five scales: 1000 mv, db above 1 mv/Mc (1 Mc bandwidth), db above 1 mv/Mc (5 Mc bandwidth), 70 db for relative measurement, and 20 db linear.



Because of its relatively small size and weight, its sturdy construction, and its choice of power sources (12 volt dc or standard 115 volt ac), the receiver is ideal for work in remote areas where extreme environmental conditions are encountered. In addition, the instrument has single-knob Unidial® tuning; three impulse bandwidths, 1 Mc, 5 Mc, and 8 Mc; and an accurate, direct-reading frequency dial.

Circle Reader Service Card 120

—*mwj*—

PRECISION WAVEGUIDE BENDING

TO YOUR SPECIFICATIONS

Bends, Twists, Offsets, Coils, Transitions, Fabrications and complete assemblies to your prints.

Specialty
AUTOMATIC MACHINE
CORPORATION

80 CAMBRIDGE ST.
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Circle Reader Service Card 58

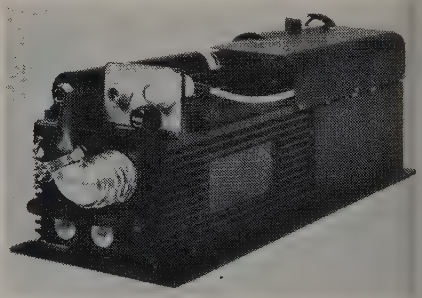
LOCKHEED DEVELOPS ACTIVE RADAR AUGMENTER

A new Active Radar Augmenter has been developed by Lockheed Electronics Co., Plainfield, N. J., for use in electronically simulating the radar echo characteristics of small, medium and large target vehicles. The company is now in production for a quantity of Augmenters to be delivered to the Air Force.

The Augmenter is intended for installation in drone or target aircraft to reinforce radar tracking facilities in missile-carrying aircraft. The unit receives the radar-transmitted signal and transmits an amplified signal back to the aircraft. It thus enables a target of small size to appear as a large radar presentation, since the radar echo is essentially enhanced as a result of the power gain characteristics of the traveling wave tube amplifier.

Typical augmenter gain at 9000 Mc is about 70 db. Assuming the transmitter and receiver line losses are equal to the antenna gains and that the antenna isolation obtainable is greater than 70 db, the simulated target area is 850 square meters. Target areas may be varied by a variable attenuator in the antenna output line.

The C/X-Band unit uses a traveling wave tube amplifier, transistorized power supplies and matched receiving and transmitting antennas. Frequency range is 5 - 11 kMc. Output power is one watt minimum although more than three watts are transmitted over a major portion of the band. Signal gain over the major portion of the frequency range is greater than 65 db and as high as 72 db. Input and output impedance is 50 ohms nominal. Input power (dc) is 100 watts with a voltage rating of 25 - 29 v dc. Regulation is one per cent. The Augmenter can be used at rated specifications in an environment of −54°C to 71°C and at altitudes up to 70,000 ft.



Circle Reader Service Card 121

—*mwj*—

HIGH-BURNOUT COAXIAL MIXER DIODES AVAILABLE FROM MICROWAVE ASSOCIATES

A new series of high reliability coaxial silicon mixer diodes with superior ruggedness and resistance to RF burnout is immediately available from Microwave Associates, Inc., Burlington, Mass.

(*Continued on page 112*)

NOW!

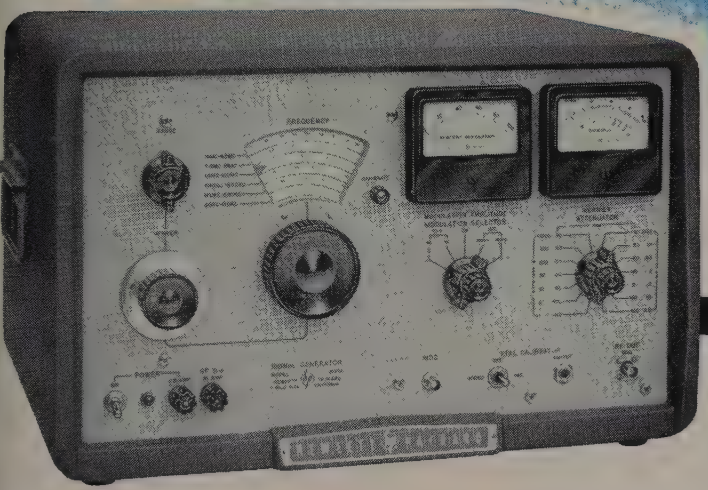
Constant output level

Constant modulation level

3 volt output into 50 ohms

Low envelope distortion

50kc TO 65MC



New *-hp-* 606A HF Signal Generator

Here at last is a compact, convenient, moderately-priced signal generator providing constant output and constant modulation level plus high output from 50 kc to 65 MC. Tedious, error-producing resetting of output level and percent modulation are eliminated.

Covering the high frequency spectrum, (which includes the 30 and 60 MC radar IF bands) the new ⓗⓟ 606A is exceptionally useful in driving bridges, antennas and filters, and measuring gain, selectivity and image rejection of receivers and IF circuits.

Output is constant within ±1 db over the full frequency range, and is adjustable from +20 dbm (3 volts rms) to —110 dbm (0.1 μv rms). No level adjustments are required during operation.

SPECIFICATIONS

Frequency Range: 50 kc to 65 MC in 6 bands.
Frequency Accuracy: Within ± 1%.
Frequency Calibrator: Crystal oscillator provides check points at 100 kc and 1 MC intervals accurate within 0.01% from 0° to 50° C.
RF Output Level: Continuously adjustable from 0.1 μv to 3 volts into a 50 ohm resistive load. Calibration is in volts and dbm (0 dbm is 1 milliwatt).
Output Accuracy: Within ± 1 db into 50 ohm resistive load.
Frequency Response: Within ± 1 db into 50 ohm resistive load over entire frequency range at any output level setting.
Output Impedence: 50 ohms, SWR less than 1.1:1 at 0.3 v and below.
Spurious Harmonic Output: Less than 8%.
Leakage: Negligible; permits sensitivity measurements to 0.1 μv
Amplitude Modulation: Continuously adjustable from 0 to 100%.
Internal Modulation: 0 to 100% sinusoidal modulation at 400 cps ± 5% or 1000 cps ± 5%.
Modulation Bandwidth: Dc to 20 kc maximum.
External Modulation: 0 to 100% sinusoidal modulation dc to 20 kc.
Envelope Distortion: Less than 3% envelope distortion from 0 to 70% modulation at output levels of 1 volt or less.
Spurious FM: Less than 0.0001% or 20 cps, whichever greater.
Spurious AM: Hum and noise sidebands are 70 db below carrier.
Frequency Drift: Less than 0.005% or 5 cps, whichever greater.
Price: (cabinet) $1,350.00 (rack mount) $1,335.00.
Data subject to change without notice. Price f.o.b. factory.

HEWLETT-PACKARD COMPANY 5023C Page Mill Road, Palo Alto, California, U.S.A.
Cable "HEWPACK" • Davenport 6-7000 • Field Representative in all Principal Areas.

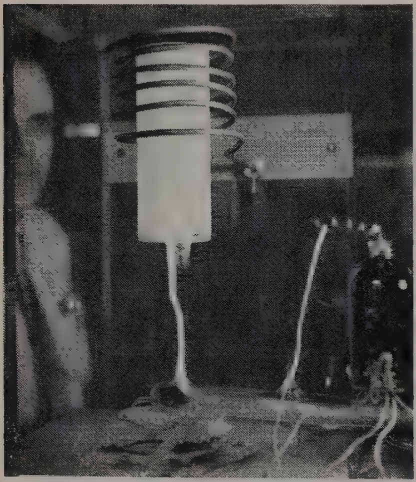
ⓗⓟ world's most complete line of signal generators

Circle Reader Service Card 59

Super processing aids Tucor TR tubes' power-handling ability

One stage in Tucor's exclusive electronic ionization processing technique is illustrated in the high-power TR tube shown at the exhaust station. Model T48U15 is a quartz, folded-cylinder tube operating at UHF and L-band frequencies with a multi-megawatt power input. This tube was designed to provide short recovery time without the disadvantages of the contaminants usually added for this purpose that shorten tube life. The addition of a newly-developed uranium getter maintains purity of the gas fill indefinitely.

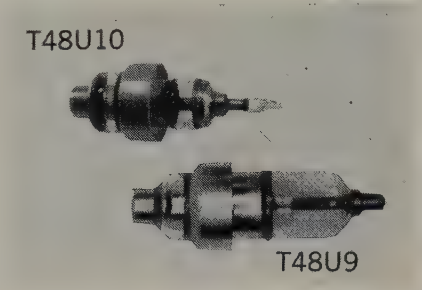
Following the duplexer stage in which such a tube would be used, a lower-powered post-TR tube circuit is usually required. Such tubes as the Tucor T48U9 and T48U10, which have been developed for this purpose as well as for use in medium-powered duplexers, provide lower leakage powers and long-life performance.



The relatively low-powered Tucor duplexers, operating over broad bandwidths, employ the same manufacturing techniques. The Tucor T48U1 and T42U1 typify a series of tubes usable from 100 mc up to approximately 1000 mc with almost 2:1 frequency coverage in each duplexer. These tubes have been built in both branch, TR-hybrid and ATR-hybrid form factors at 1 kw average power. A complete duplexer employing these two tubes, the T4248U1D, covers a frequency range of 225-400 mc with an average power input of 1000 W.

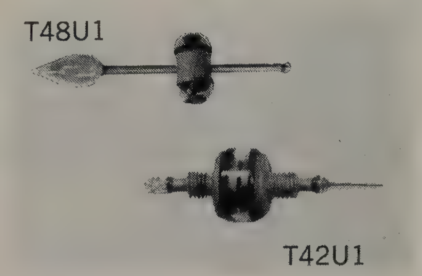
Why do Tucor tubes perform better? A combined microwave circuit and plasma physics design results in an optimum configuration and gas fill for any application. Tucor processing know-how insures reliability and long life.

Whether shelf items or custom designs for your specific application, Tucor tubes provide advantages in reliability. Why not investigate further by asking for our latest tube catalog?



T48U10

T48U9



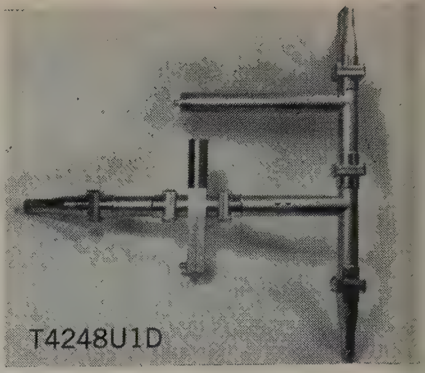
T48U1

T42U1

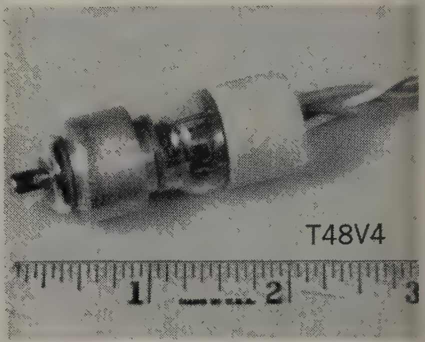
TUCOR ELECTRONICALLY PRIMES TR TUBES

Wilton, Conn. — Tucor announces a breakthrough in TR tube design. The conventional TR tube requires the buildup of large RF voltages before the TR tube will "fire" and provide the high attenuation of which it is capable. These initial high RF voltages appear on the transmitted pulse as a spike containing large amounts of energy. This energy is often sufficient to damage the sensitive circuits which follow.

Tucor has now developed a type of TR tube which does not require the buildings of high RF voltages in order to initiate its attenuating function and, therefore, performs in such a fashion as to virtually eliminate spike leakage. In most cases this technique also allows an improvement in total attenuation characteristics and in recovery time characteristics. Such a tube is the T48V4.



T4248U1D



T48V4

In specific cases, Tucor's new electronically-primed TR tubes have been built to have a spike leakage only 3 db above flat leakage and a recovery time without sweeping voltages superior to conventional tubes with sweeping voltages.

The new technique of electronic priming can be incorporated in tubes of conventional size which are interchangeable with most standard units. Tubes have been built in a variety of sizes suitable for use in ⅞″ coax line, 1 ⅝″ coax line, 3 ⅛″ coax line and L-band waveguide cavities.

If your application suffers due to spike leakage, these tubes are undoubtedly your cure. Please let us know your problems.

TUCOR INC.

59 Danbury Road (Route 7), Wilton, Connecticut

Circle Reader Service Card 60

COMPANY PROFILE

POLARAD ELECTRONICS CORPORATION

Long Island City, New York

"The blending of money and talent are not enough to assure long term growth in the electronics industry. While new products and new markets are a measurement of prosperity as truly as they are the fruits of applied science, a corporate philosophy from which realistic objectives follow, always must guide both capital and creative imagination to produce the overall results that are characterized as growth."

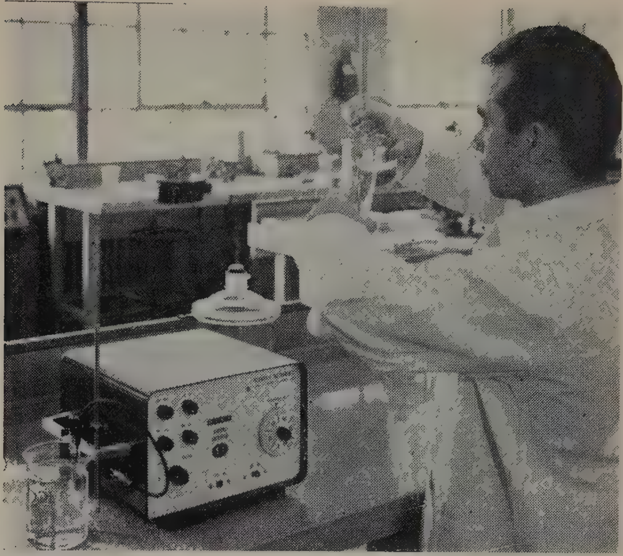
These are the words of Dr. D. Lawrence Jaffe, President of Polarad Electronics Corporation, in a recent address to a group of businessmen. Their soundness was extracted from the experience of many years of directing and inspiring the men who form the Polarad organization.

This philosophy put into practice resulted in placing Polarad in the foreground of the dynamic growth which has taken place in the microwave electronics industry. Significant contributions to development progress in the microwave electronics field have been made by Polarad. Some of the most significant "firsts" include broadband spectrum analyzers; spectrum analyzers operating to 100,000 megacycles; the first industrial line of microwave receivers to 84,200 megacycles; signal generators operating to 50,000 megacycles; transistorized power meter; electronically tuned microwave sweep generators; transistorized microwave test equipment; microwave spectrum tape recorder; microwave tube tester; broadband microwave multipulse generator; pulse jitter tester; and microwave spectrum decoder.

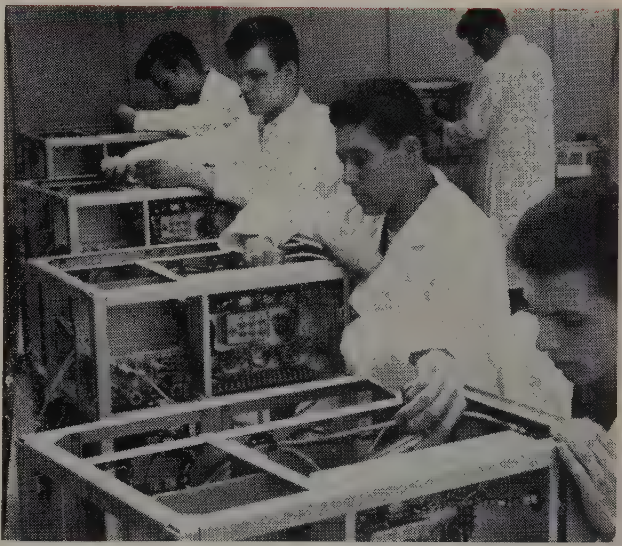
The cumulative experience gained from these achievements, in addition to engineering know-how, has made Polarad one of the largest manufacturers of microwave test instruments and a significant producer of other related electronic equipments and systems.

History

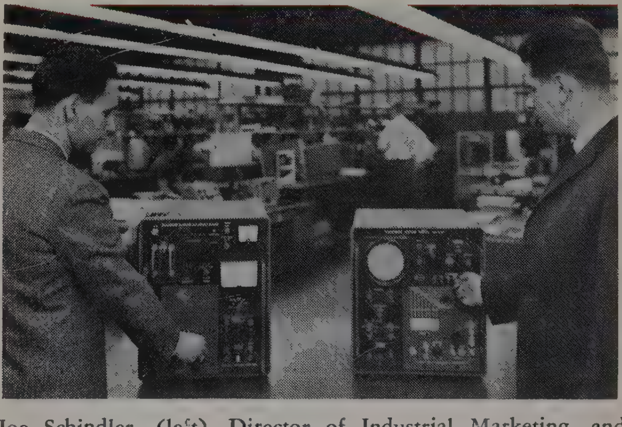
A simple advertising slogan, "proven reliability," which became a company policy, started with the desire of two men to develop and manufacture microwave test instruments that would provide more reliable operation together with greater accuracies required for dependable performance than existed in the field at that time. The determination to provide quality instruments for operation in



A Polarad technician prepares the Model DpH-1 Digital pH Meter for analyzing a solution in the Scientific Instruments Division.



Short run pilot production of a limited quantity of units is conducted under optimum conditions of cleanliness and precision.



Joe Schindler, (left), Director of Industrial Marketing, and Project Engineer Bernard Liebowitz demonstrate addition to the industrial product field of a complete line of transistorized microwave test and measuring equipments. The new designs constitute advances in the mobile operation of microwave equipment, both battery and power line operation, and reduced size and weight characteristics.

the relatively unexplored microwave frequencies region prompted Dr. Jaffe and Paul H. Odessey to found Polarad Electronics Company as a partnership in 1945. The new company, with only a handful of engineers, started its operation in a small laboratory in New York City.

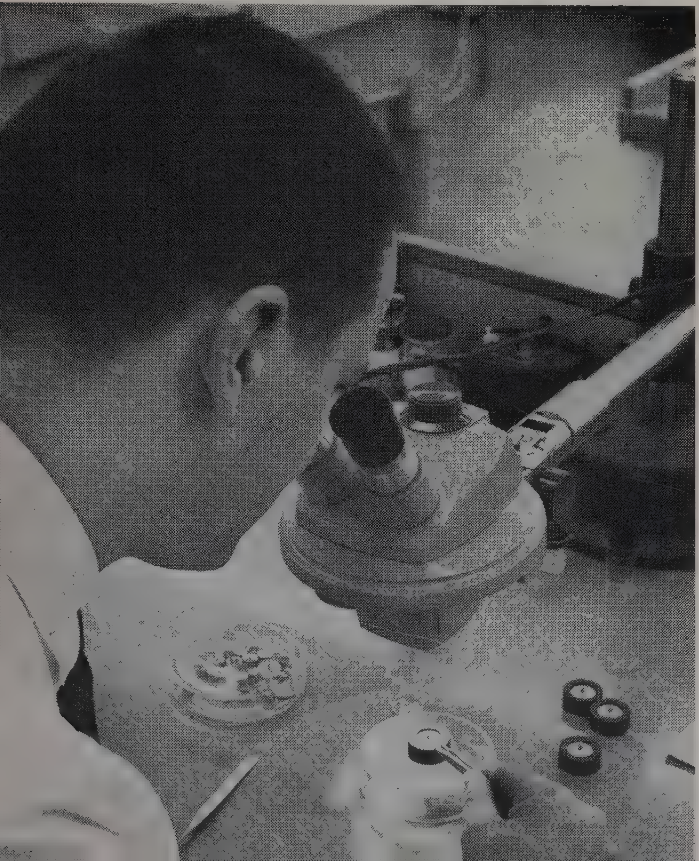
From a modest beginning in cramped quarters, Polarad began designing and manufacturing new types of microwave test instruments. The company quickly achieved a prominent reputation in the field of microwaves, which subsequently led to diversification to other fields of interest and scope of activities. Polarad was incorporated under its present name in 1949.

As expansion continued and sales climbed, the company was forced to move several times to larger quarters. Polarad's steady growth has required substantial year-by-year enlargement of its facilities, both research and development and manufacturing. Today, Polarad has a combined employment of approximately 1000 persons and occupies four buildings, totaling 250,000 square feet, in Long Island City, New York.

Corporate Philosophy

The philosophy of Polarad, symbolized by its "proven reliability" tradition, has been one that strives for the design and development of propriety components, instruments, and techniques that represent the ultimate in the state-of-the-art in microwave equipment design and manufacture. In recent years, the company has diversified its interests into related fields with the emphasis on research and development and manufacturing techniques while constantly improving the quality and reliability of operation which characterize the Polarad developed instruments and systems presently in use throughout the world.

Tube Lab Manager Maurice Cunniffe assembles a Polarad Velocitron using a precision microscope. Use of the microscope is necessary because of the intricate components incorporated in the device.



Current Activities

The demand for microwave electronic instruments for use in radar, navigation, countermeasures, and communication systems, as well as in missile and other military programs has increased greatly since 1945. As a result, Polarad placed heavy emphasis on the design, development, and manufacture of instruments and systems operating in the microwave range. In addition to military instrumentation, the company produces a complete line of industrial microwave test and measuring instruments. These instruments cover every aspect of the generation, detection, and analysis of microwave and RF energy from low frequencies through the infrared region.

Polarad has developed, designed, and marketed more than 400 different industrial instruments. The company's present catalog, incorporating the latest designs, lists more than 250 equipments covering frequencies from 0.001 cps to 100,000 megacycles.

To service the growing demand of the European electronics common market, a French subsidiary, Polarad-France, was organized to manufacture and maintain Polarad's microwave equipments.

The merchandising responsibility of Polarad's industrial products is directed by Joe P. Schindler, head of the Industrial Marketing Division. Mr. Schindler has been associated with Polarad for the past 10 years and before his appointment as Industrial Marketing Director served as Manager of the Ground Support Equipment Division in the engineering department.

The company places heavy emphasis on the advancement of the state-of-the-art with the development of new and improved equipments providing a variety of applications. Toward this end, Polarad has continued to improve its product line formulating advanced techniques and functional designs.

The company maintains complete facilities for the production and testing of all equipments and systems designed by its engineering staff. This facility is under the supervision of Robert Saul, Director of Manufacturing. Mr. Saul has been an employee of Polarad for 11 years and before appointment to his present position, was Chief Test Engineer.

A significant portion of Polarad's activities and facilities is directed toward military and national defense programs. The company's Defense Products Division is engaged in highly classified projects for countermeasures applications, anti-submarine warfare, reconnaissance, and missile and space technology.

Polarad recently acquired, as a wholly-owned subsidiary, Federal Scientific Corporation of New York City and its staff of highly prominent scientists and engineers. Federal Scientific has become known through its work in the fields of theoretical analysis, information theory, acoustics, and advanced radar and space technology. The company's SIMORAMIC+* analyzer is a low frequency spectrum analyzer, complementing Polarad's line of high frequency analyzers.

Dr. Robert I. Bernstein, Associate Director of the Electronics Research Laboratory, Columbia University, is

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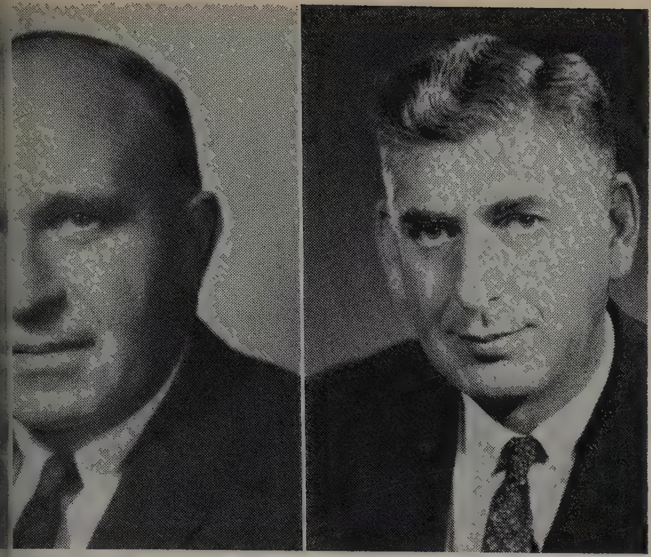
+ *registered trademark*
* *patents pending*



Dr. D. Lawrence Jaffe (left), President of Polarad Electronics and Executive Vice President Paul H. Odessey.

Chairman of the Board of Federal Scientific and Henry J. Bickel is Chief Engineer and President.

The Defense Products Division has designed, developed, and produced electronic systems, sub-systems, and equipments for such defense programs as Atlas, Vanguard, Mace, Matador, the B-58 Hustler, Bomarc B, Hawk, and the NIKE-ZEUS anti-missile missile. Present work encompasses anti-submarine warfare, miniature and sub-miniature transistorized countermeasures systems, RF interference measuring systems, and infrared detection and generating systems.

Technical insight is a necessity for the successful marketing of military systems and equipments for use by military personnel. Polarad's Defense Products Marketing Division is directed by men having both marketing and technical experience in the design, development and application of reliable military electronic systems. A. H. Sonnenschein, with the company for more than 10 years, was formerly Chief Systems Engineer, Director of Planning, and Technical Assistant to the President. Associated with Mr. Sonnenschein is Kenneth O'Neil, formerly Director of Contract Relations. Mr. O'Neil has many years of experience in military maintenance engineering and sales management.

Because of the many military projects Polarad has participated in, it has found that to maintain equipment reliability and adherence to specifications, complete testing facilities must be readily available. Thus, Polarad maintains a variety of test and measuring installations at its own facilities. These range from altitude chambers, antenna test ranges and environmental test chambers to complete vibration and shock testing apparatus. All test instrumentation is under the direction of the Quality Assurance Department.

Subordinate divisions operate within the Polarad organizational framework. One such division is Scientific Instruments, headed by Charles French. This closely-knit group of engineers, scientists, and technicians design, develop, and produce a variety of electronic instruments for use in the medical, biological, chemical, and related scientific industries. They have produced instruments such as the rotating cylinder viscometer for measuring viscosities of liquids, an automatic recording titrator for performing variable pH and constant pH titrations automatically, and an automatic self-balancing digital pH meter which determines the acidity, alkalinity or potential of a solution.

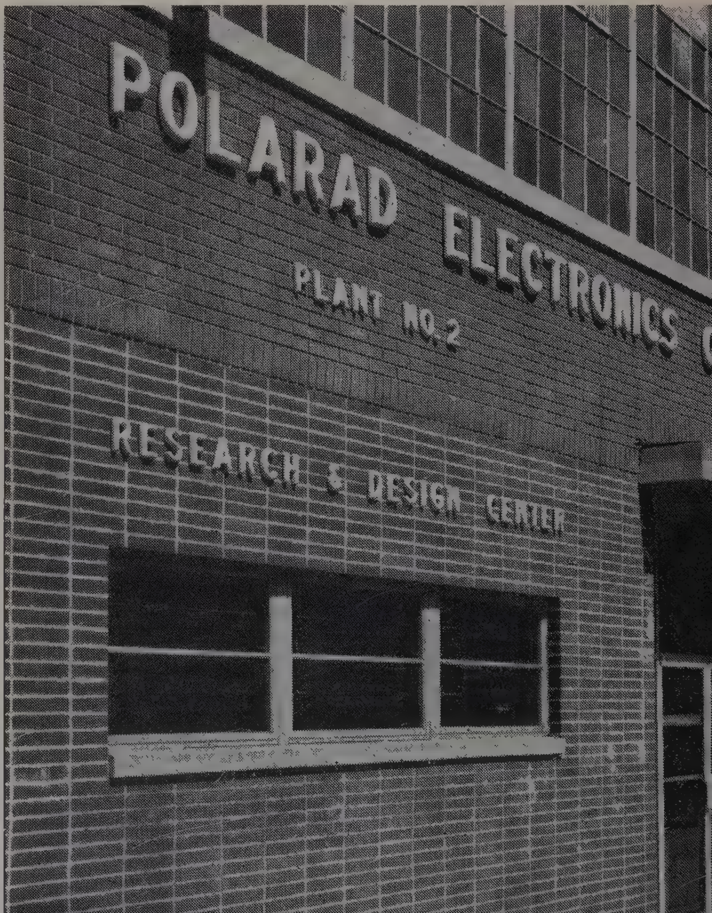
Another of these subordinate divisions is the Tube Laboratory, headed by Maurice Cunniffe, where the rugged Polarad Velocitron® Microwave Oscillator Tubes are developed and produced. The formation of this division was necessary to complete the successful design of some of the company's microwave instruments.

Through careful investigation of available industrial products of this nature, it was realized that for instruments to achieve the desired performance as well as to operate more reliably and for longer periods without breakdown, a precision microwave oscillator of rugged construction and advanced electrical characteristics was a necessity. This then, was the objective of the Tube Laboratory. Today, the Tube Laboratory designs and produces ceramic and metal sealed klystrons which operate from 500 to 11,000 megacycles and feature heat and shock resistance as well as low distortion FM and non-microphonic characteristics.

Organizational Structure

Polarad was operated as a partnership from 1945 to 1949. In the latter year, Polarad Electronics Company was incorporated in the State of New York and thus became Polarad Electronics Corporation. During the following years, the company was privately-owned and operated and prospered under the leadership of Dr. Jaffe and Mr. Odessey. Subsequently they were joined by Charles J. Eisen and Frank J. Skwarek, financial and engineering executives, respectively.

Main entrance of Polarad Research and Design Center in Long Island City, New York.



Management's foresight and planning brought the sales figures from a low of several hundred thousand dollars to 12 million dollars in 1959. On June 25th of that year, Polarad made its first public sale of 100,000 shares of common stock which was promptly over-subscribed. Now a publicly-owned corporation listed on the American Stock Exchange, Polarad's growth has continued and today enjoys a prominent position in the industry with annual gross sales of approximately 15 million dollars.

Polarad's future growth prospects have been planned on a five year basis with some 25 new company-sponsored development projects in various stages of completion. These new developments are expected to generate upwards of 10 million dollars in new sales volume by 1966, and additionally strengthen Polarad's position.

Many benefits are realized by the company's operating personnel thereby providing the incentive and spirit necessary to maintain a leadership position. In addition to hospital and surgical plans, life insurance and compensation, Polarad has a generous profit sharing plan for all salaried personnel as well as stock options for key employees.

Technological advancement and individual proficiency is encouraged by a program of courses in the specific fields of interest to personnel within the company. A full tuition reimbursement plan is in effect for those employees wishing to continue their education at accredited schools and to obtain engineering degrees related to their specific design areas. Regular attendance at American Management Association courses is prescribed for all department heads and other key personnel. The total program for the benefit of the company's employees is additional insurance in Polarad's future in that it continues to benefit from the type of professional employment that is vital to a progressive and growing company.

Key People

The management team is headed by Dr. D. Lawrence Jaffe who is presently Corporate President and Chairman of the Board. Dr. Jaffe has the distinction of being the second man ever to receive the Ph.D. degree in electrical engineering from Columbia University. He was awarded his doctorate in 1940 after completing his masters at Columbia, following undergraduate work at the City College of New York.

Robert Saul (left), Director of Manufacturing, and Leonard DiSalvo, Production Manager, inspect equipment chassis in early stages of assembly and wiring.

Dr. Jaffe's experience dates back to the late 1930's when he was engaged in development of frequency modulation with the late Professor Edwin H. Armstrong. In 1942 he joined Raytheon Manufacturing Company, where his research activities led him into the field of radar and related microwave components and instruments.

After co-founding Polarad in 1945, Dr. Jaffe continued his research and engineering activities along with his major management responsibilities. He has personally initiated many of the company-sponsored projects as well as new scientific developments.

An original partner in the company and a dynamic force behind the growth of Polarad is Paul H. Odessey. Mr. Odessey is executive Vice President of the Corporation and is also responsible for the marketing and manufacture of Polarad's industrial instruments. He received his BSEE cum laude from Polytechnic Institute of Brooklyn in 1935 and his MSEE degree from the same institution in 1937. He launched his technical career when in 1935, while still an undergraduate, one of his technical papers won the national AIEE prize.

Mr. Odessey met Dr. Jaffe during his employment at Raytheon as a senior engineer. Shortly thereafter, they co-founded Polarad for the expressed purpose of designing and producing quality microwave equipments and systems.

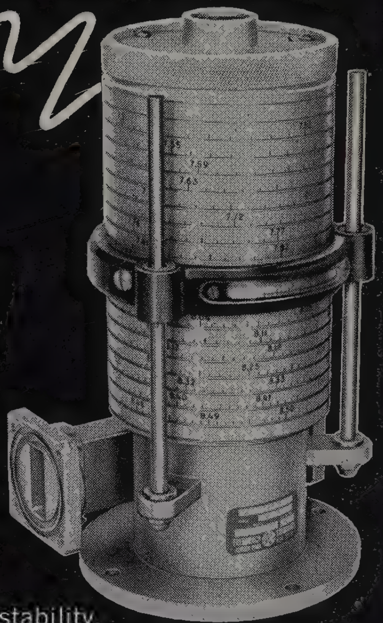
Mr. Charles J. Eisen is the Vice President and Treasurer of the Corporation and has the responsibility of providing financial guidance and direction of Polarad's operation. Mr. Eisen is a graduate of New York University's School of Commerce, and a certified public accountant. He joined the Polarad organization as treasurer in 1952, relinquishing a successful partnership in a public accounting firm, and was appointed to his present position in the corporation in 1958. His work as Chief of the Audit Branch of the Signal Corps, with a rank of captain during World War II, was appropriate experience for his present executive financial duties.

The Defense Products Division, whose prime responsibility is that of designing, developing, and producing electronic systems for our national defense, is directed by Frank J. Skwarek, Vice President of this division. Mr. Skwarek, is a graduate of Northeastern University and a licensed professional engineer. His professional experience includes employment in product engineering, design and development for the Sperry Gyroscope Company, MIT's Instrumentation Laboratory, the Doelcam Company and Raytheon. He joined Polarad in 1951, was named Manager of Engineering Operations in 1954, and advanced to Vice President of the Defense Products Division in 1956.

Polarad is proud of its record in the electronics industry and its many contributions to the advancement of the state-of-the-art and the safeguarding of our national defense. Its management team and skilled staff of employees are continually striving to make better products available to its industrial and military customers. Toward this end the Polarad slogan of "proven reliability" is continually the by-word and is inherent in every system designed and produced by the company.

Direct Reading Microwave Wavemeters

Proven in Performance and Reliability .01% Accuracy



Covering a frequency range of 500 mc to 18 gc with .01% maximum error, Frequency Standards' precision-engineered wavemeters combine greater accuracy of readout with a broader frequency range in both absorption and transmission types. Each unit provides direct readout **without chart** and is individually calibrated and temperature compensated for a high degree of accuracy and stability. Higher accuracies can be obtained depending on other limitations.

Frequency Standards, America's foremost center for new ideas in microwave technology, produces this precision wavemeter in absorption, termination, and RF transmission styles both for laboratory and operational applications. For outdoor use a direct reading model is furnished in a ruggedized waterproof carrying case. **Delivery within 10 days** ● For information on the complete line of wavemeters, write for catalog P-26102.

Certified: All wavemeters are calibrated against standards originating with the U. S. National Bureau of Standards.

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FREQUENCY STANDARDS
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Center for Microwave Components: Wavemeters • Reference Cavities • Signal Sources • High Power Filters • Discriminators • Antenna Couplers • Diplexers • Duplexers • Directional Couplers • Antennas • Cavities

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signal hide and seek...

planned through advanced communication techniques at Amherst Laboratories

Signal transmission can be protected and hidden from interception by using natural or man-made disturbances. Locating such a signal in intelligible form at a designated point has been accomplished by scientists at Amherst Laboratories.
These and other accomplishments are a result of long-range experimental investigation currently in progress. We are concerned with wave propagation and properties of the propagation medium, as applied to advanced Ground, Air and Space Communications.

PROFESSIONAL STAFF AND MANAGEMENT OPPORTUNITIES *are unlimited for Physicists, Mathematicians and Electronic Engineers with advanced degrees and creative desire.*
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SYLVANIA ELECTRONIC SYSTEMS
Government Systems Management
for GENERAL TELEPHONE & ELECTRONICS

"Shrinking the Universe . . . through Communications"

New Products

(*Continued from page 104*)

The MA-445 series diodes are rated at 1.0 erg burnout to insure resistance to RF burnout or electrical deterioration. Guaranteed high-temperature performance at 150°C and true all-solder hermetic sealing assures top reliability under the most stringent environmental conditions.

Primary applications include use in single or balanced mixers, or for improved sensitivity and dynamic range in special applications such as AFC feedback loops, CW modulators, and for test equipment applications. For radar applications in the 10 - 18 kMc region, the MA-445 series provides high reliability performance when used in receivers exposed to stray radiation fields, spike leakage of duplexer tubes, voltage transients developed along IF input connecting cables and metering circuits.

The MA-445 series is available in three (3) forward polarity units (MA-445, 445A, and 445B), three reverse polarity units (MA-445R, 445AR, and 445BR), and in forward and reverse polarity matched-pairs (MA-445M, AM, BM, MR, AMR, and BMR).

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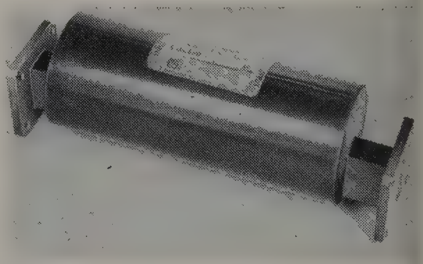
CASWELL OFFERS BROADBAND ISOLATORS FOR MEDIUM POWER RANGE



Five new ferrite broadband load isolators have been announced by Caswell Electronics Corp., San Jose, Cal.

The new series of waveguide isolators features excellent isolation and insertion loss characteristics and is designed primarily for use with medium power microwave equipment. Substantial price advantages are offered to end equipment manufacturers even in medium size production quantities.

The isolators are constructed under Mil Standard techniques, mating surfaces are silver plated to minimize tarnishing, and military-type brass or aluminum flanges are used, with special flanges supplied upon customer request. Units are finished in durable, dark-green baked enamel.

Circle Reader Service Card 123

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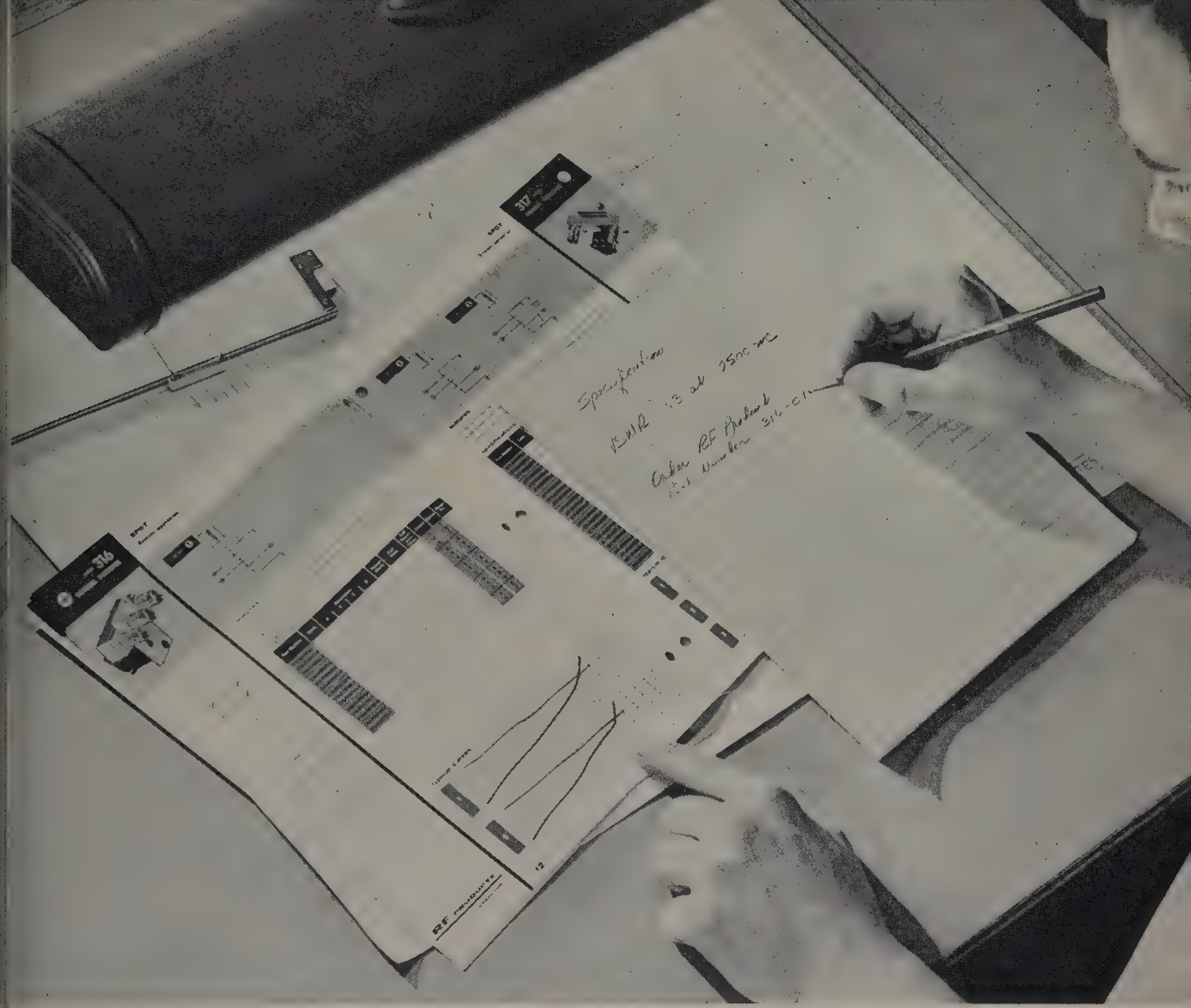


Now, you can save time and insure reliability... by specifying DK Coaxial switches in your design

It's easy. DK Coaxial switches are available in scores of shapes, sizes, and functions *from factory stock.* RF Products' new DK Coaxial switch catalog lists over 130 variations of 16 basic coax switch designs, covering a proven 90% of all known applications. All the facts and figures on the industry's most complete line of coaxial switches are at your finger tips.

You'll also find that these switches successfully combine ruggedness with the highest standards of precision: spring-leaf switching blades, gold-plated silver contacts and impedance matched connectors keep insertion loss and VSWR (1.3 @ 4,000 MCs) low, Crosstalk high (in decibels down); electro-mechanically actuated models operate and release in 8 to 20 milliseconds, depending on type and function, with a proven mechanical life of 1,000,000 cycles minimum when operated under 10 cps.

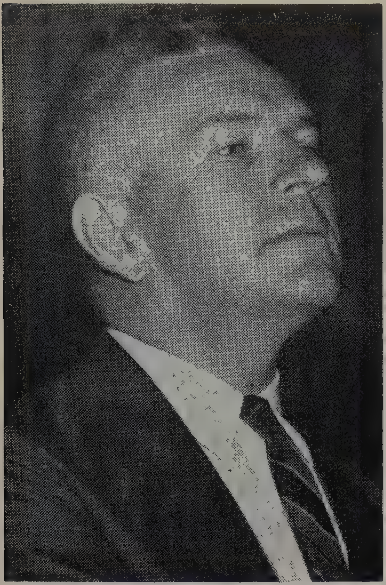
And, don't forget that RF Products, pioneers in the development of the coaxial switch, will continue to offer you design and engineering services whenever you need them. Whether you order a switch from the catalog or a switch designed to meet your exact specifications, you can be assured of the same high quality and service.

For details on our new line of standard switches, write for catalog DK 61.

RF PRODUCTS DK ipc AMPHENOL
DIVISION OF AMPHENOL-BORG ELECTRONICS CORPORATION • 33 EAST FRANKLIN ST., DANBURY, CONN.

Circle Reader Service Card 62

"IT WAS A NIGHT OF SWEET TRIUMPH . . ."



Ivan Serov

PGMTT BANQUET 1961

By TED SAAD
Technical Editor
the microwave journal

Dr. George C. Southworth

Although some of you may have heard the story of the 1961 PGMTT Banquet, it is a story that bears repeating.

Late in 1960, Dr. John R. Pierce of Bell Laboratories had been invited to speak at the 1961 PGMTT Banquet. He had accepted, and all appeared to be under control. About two months prior to the Symposium, he was obliged to withdraw himself due to some conflicting meetings abroad.

At that time Gus Shapiro, who was on the Steering Committee of the Symposium, assured the PGMTT Administrative Committee that he would make arrangements for a speaker. He refused to elaborate beyond the assurance that the talk would be of great interest to everyone.

Other than for an occasional comment by Gus, nothing more was said about the affair until the Sunday night before the Symposium was to begin. That night, all were advised that the talk would be one that no one could afford to miss. I was privately advised to bring a notebook and a pencil.

Little more was said about the banquet during the next two days. On Tuesday, Gus called me out of one of the sessions on a matter of some importance.

He swore me to secrecy and then explained that he had invited a Russian official to speak on the microwave industry in Russia. The reason for the secrecy, he explained, was to prevent the non-technical press from attending and, thereby, possibly embarrassing our guest. Gus further explained that his guest had agreed to a question and answer period. The guest had been warned that the questions might be delicate, but he nevertheless expressed a willingness to participate. To insure the success of the questioning period, Gus decided to plant a few key questions in the audience. He felt this would help stimulate the discussion. My question was: "The U. S. always announces its atomic explosions. Why hasn't Russia done the same?"

At the cocktail party prior to the banquet a few people met the guest of honor. I imagine by most standards he was a typical looking Russian — stocky, medium height, greying, with an arrogant yet suspicious look on his face. He was introduced as Ivan Serov. He spoke with a heavy accent, but he could be understood. A few of the guests had their picture taken with him!

Later, after everyone had eaten and the dishes were cleared away, Gus, in a style all his own, proceeded to introduce the people at the head table. The first speaker on the program was Dr. Southworth, who gave an absorbing 20 minute discussion on a few of the highlights of his illustrious career, dating back to the beginning of microwaves.

At the conclusion of Dr. Southworth's talk, the guest speaker, Mr. Ivan Serov, was introduced. Gus pointed out that in 1959 the Department of Commerce had sponsored and conducted the American National Exhibition in Moscow. Some of the members of the Department of Commerce became acquainted with those Soviet authorities interested in cultural and technical exchanges with the United States. He went on to say that one of those gentlemen was a Mr. Ivan Serov, who made a very favorable impression with his outspoken frankness.

About the time he received Dr. Pierce's letter of regret, Gus learned that Mr. Serov was visiting this country. He communicated with Mr. Serov and was delighted to learn that he would discuss for us the technological developments in the microwave field now being conducted in his country. Gus went into further details about his background and specialties and also the reasons for his being in the country at this time. Then Mr. Serov addressed the group.

He started out by explaining that, although he was not an engineer, his position was equivalent to that of a member of management in a large engineering combine. Since he was not technically trained, he was obliged to confine his comments to those details of a relatively general nature.

ITEM: Russian engineers are working hard to close the gap that exists between the millimeter wave frequencies and light frequencies.

ITEM: About four years ago, the invention of a new type of coherent energy generator made possible the development of a family of rugged signal sources having an output in the order of one watt, with 2 to 1 frequency tuning range and extending up to 500 kilomegacycles.

ITEM: Similar in principle to the generators described above is a lower frequency device that can continuously deliver 100 megawatts of power at a frequency of .5 kilomegacycles. They find it difficult, however, to modulate this generator.

ITEM: The two-way communication during re-entry of a space vehicle in their standard S-band frequency region which is vital to the proper maneuvering of the space vehicle was blacked out for several seconds by the highly ionized sheaths surrounding the vehicle when reentering the atmosphere. The problem was solved by introducing a strong static magnetic field surrounding the space vehicle which generates new modes of propagation and thus eliminates the communication blackout.

ITEM: They have found ways of using a low loss atmospheric waveguide principle to transmit microwave signals over thousands of miles using only milliwatts of high frequency electromagnetic energy.

ITEM: In their current types of space vehicles they anticipate that reliable communication will be made by using the ionized exhaust gas as the radiating element for low frequency transmissions. Part of their success with this technique is due to their ability to control the geometry of the ionized exhaust of their rockets.

ITEM: In the areas of microwave circuit and component development, their engineers are building into microwave equipment, non-reciprocal transmission devices containing neither electronic nor solid state elements and having uniform performance over very large temperature changes.

ITEM: They read in the American technical literature, speculation about the transmission of microwave power sufficient to support space platforms. Recently they have held small platforms at a height of several kilometers and a very limited area of a square kilometer in spite of high velocity variable air currents, by using some of the energy transmitted to the platform to produce position correcting propulsion.

ITEM: Their engineers have built an experimental Optical Radar Lazer that can map topography in fine relief detail. They expect this to be a great aid in connection with landings of their space craft on the moon and elsewhere.

ITEM: Their ability to focus the energy output of their larger lasers into an infinitesimally small area on a target surface has permitted engineers to help medical experts develop new microsurgery techniques instead of death ray devices to which these techniques could also apply.

He mentioned that his colleagues had cautioned him that the American engineer tends to disbelieve and discount those accomplishments that surpass his own. In spite of that he said that he tried to convey to us some of the exceptional advances the USSR has made in the microwave field. He further pointed out that it was not surprising that they were able to accomplish so much so rapidly. The reason he gave was that the Soviet engineer is not distracted by those frivolities that prevent the engineers in the Western world from concentrating on the immediate technical goals. He also mentioned that the superiority of their educational system cannot help but produce a disciplined and superior technical structure.

He said that they admired our production techniques and they were interested in our forthcoming plastics exhibit.

Many of us were frightened by his talk, to say the least. The only conclusion we could draw was that either we were badly out-distanced or it was a complete fabrication.

During the time he was speaking, several people were frantically taking notes. There was hardly a smile in the audience.

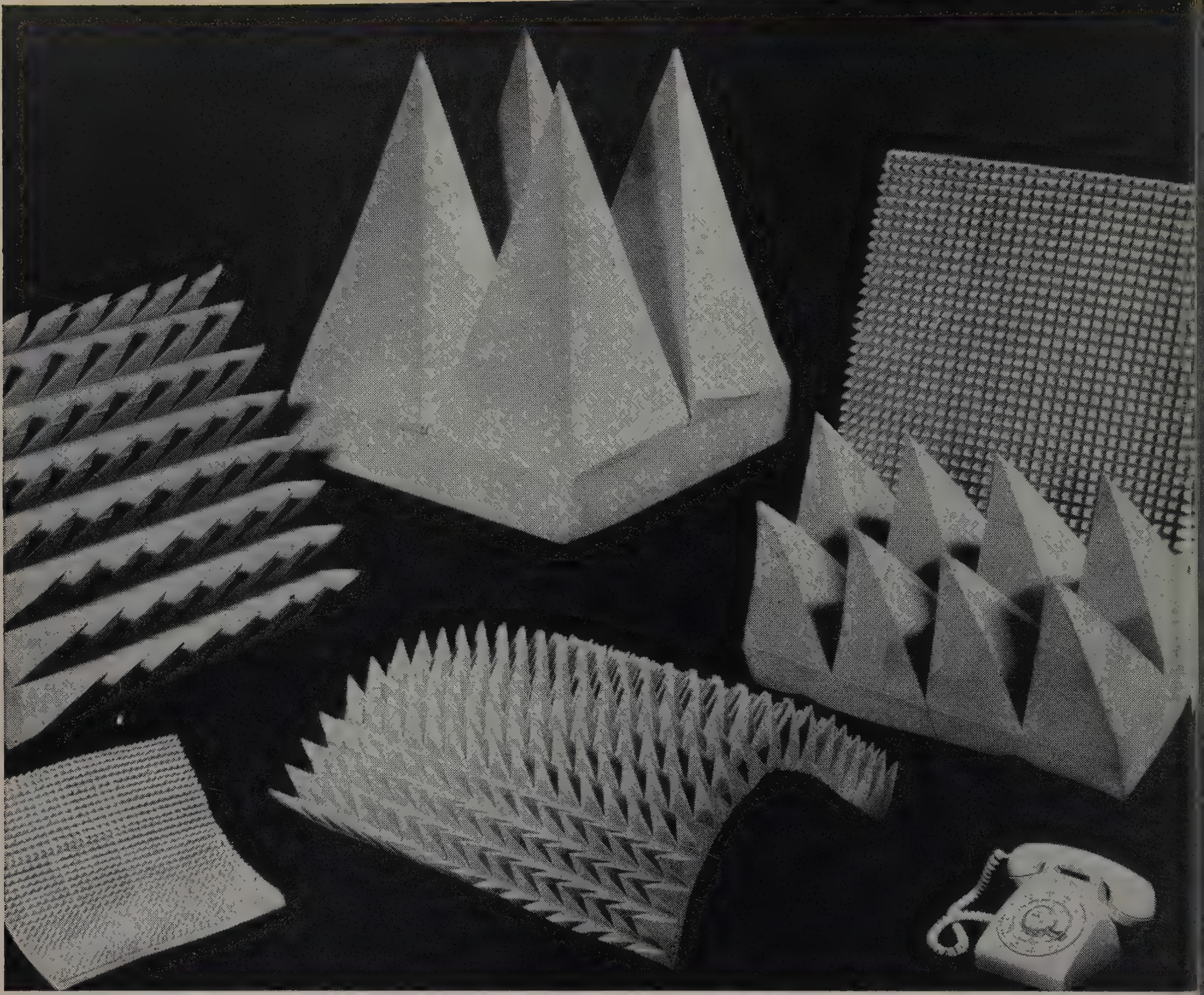
The question and answer period began. There was no need for any planted questions, as it later turned out. Several people were on their feet immediately, anxious to ask all sorts of questions. Mr. Serov dealt with the problems of exchange of students, secrecy in space work, development of trade, copyright, and patent negotiations, in typical Russian fashion. He agreed to furnish the name of the person and the university from which further information on the submillimeter wave generators could be obtained.

All in all, it was a very sobering experience.

Then Gus called a halt to the question and answer period and was about to conclude the banquet when he noted a gentleman in the audience. He felt that in view of the tone of Mr. Serov's talk and the discussion that followed, it would be advisable to ask the gentleman to present a short rebuttal. He then prevailed upon Mr. Paul R. Conroy of the U. S. Information Agency to comment on Mr. Serov's remarks. The entire audience was dumbfounded as the stocky, greying, suspicious-looking Mr. Serov approached the podium and revealed that he, in truth, was Dr. Conroy of USIA. He pointed out that the entire talk was a hoax and was so designed as to help educate and alert people to the workings of the Russian mind — this, incidentally, in perfect English.

The meeting broke up in sheer chaos. Of the 180 attendees, to my knowledge not one saw through the disguise. It was a lesson many of us will not forget too readily. It was a night of sweet triumph for Gus Shapiro.

Left to right, Ivan Serov, Gus Shapiro and Ted Saad.



Absorbers take new shape to provide very high performance

B.F.Goodrich "sharp-point" design improves testing reliability in anechoic chambers

These newly-developed VHP (very high performance) broadband microwave absorbers can substantially improve the performance of anechoic chambers.

They can eliminate baffles yet provide chambers with lower reflection levels than previously existed. They can improve the performance of existing chambers by application to rear wall and/or center region. Their inherent high attenuations eliminate the need of additional metal shielding where moderate isolation is required. And because of Type VHP's excellent wide-angle absorption, chambers with reduced cross-section area can be used.

To take a specific example, Type VHP-18 at X band offers these outstanding electrical features.

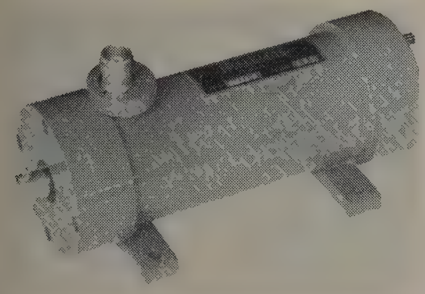
- Reflection down by approximately 60 db for angles near normal incidence.
- Reflection down 40 to 50 db for both polarizations at angles of 60° to 65° from normal incidence (angles most often encountered in anechoic chamber sidewalls).
- Attenuation through the material in excess of 50 db.

B.F.Goodrich VHP absorbers are light, semi-flexible, easy to install. A variety of thicknesses, as shown in picture, enables the engineer to choose the desired absorption level and frequency range. If you would like more information on VHP absorbers, or want to know more about an entire line, just write *B.F.Goodrich Sponge Products, 130 Derby Place, Shelton, Conn.*

MICROWAVE ABSORBERS BY B.F.Goodrich

(*Continued from page 112*)

WAVELINE OFFERS TRIODE MICROWAVE OSCILLATORS



Waveline, Inc., Caldwell, N.J., offers a new line of standard Triode Cavity Oscillators covering the frequency range of 2500-3900 Mc. Another standard model CW Oscillator utilizing the GL-7391 tube covers the frequency range of 5400-5900 Mc.

These standard oscillators feature a single frequency tuning control and power output adjustment which is normally preset to provide the minimum power of the entire frequency range. All of these oscillators operate from a 200 volt plate power supply and can draw up to the maximum current specified by the electron tube manufacturer.

The units are designed to provide maximum performance under extreme environmental conditions by incorporating integral mounting provisions as part of the oscillator housing, as well as rigid support for the electron tube and a rugged tuning drive system.

In addition to the standard oscillators, special CW and pulse oscillators can be designed to meet special systems design parameters.

Circle Reader Service Card 124

—mwj—

GABRIEL ELECTRONICS BUILDS ANTENNA CALCULATOR

Gabriel Electronics, Millis, Mass., has announced the availability of new calculators covering frequencies from 30 - 30,000 Mc.

The calculator was designed to simplify the computations for determining the parabolic antenna parameters in microwave antenna systems. The scales include frequency, wavelength, beamwidth, VSWR, windloading and focal length, as well as spectrum scale for band designation, conversion scales for inches — centimeters and VSWR — return loss.

The Gabriel Antenna Calculator is available for $2.00.

Circle Reader Service Card 125

—mwj—

(*Continued on page 118*)

Doppler Noise Measurement

The ALLSCOTT Noise Measuring Equipment

PROVIDES:

1. The ability to distinguish between frequency and amplitude modulated noise and to present these spectra independently and with adequate isolation.
2. A narrow-band filter or "window" which may be located for the purpose of making noise power measurements at an accurately known frequency separation from the carrier.
3. A high order of sensitivity.

CHARACTERISTICS:

AM Signal to Noise Ratios in the range — 135db to — 85 db. RMS
Frequency Deviations of 0.01 cps in a 70 cps bandwidth within a band of frequencies 1.0 to 90 Kc/s.
Units available for RF frequencies from 8 to 14 Kmc/s.
Oscilloscope display with automatic sweep to give spectrum curve.
Thermal microammeter and manual oscillator control for quantitative work.

F FERRANTI

FERRANTI ELECTRIC, INC.
ELECTRONICS DIVISION
INDUSTRIAL PARK PLAINVIEW, L. I., N. Y.

Circle Reader Service Card 63

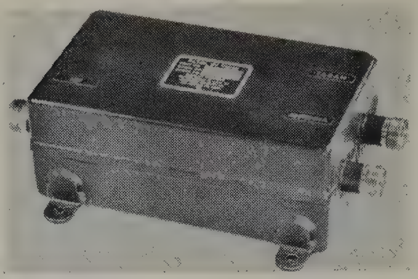
(*Continued from page 117*)

ELECTRONIC SPECIALTY GRANTED PATENT FOR SMALL DIPLEXING FILTER

Patent rights to a new small size Diplexing Filter have been granted to Electronic Specialty Co., Los Angeles, Cal., according to William H. Burgess, president.

Designated DP-318, the filter is employed in the ESCO-designed IFF/TACAN System utilized by military aircraft. The system increases effective antenna coverage while reducing the number of antenna installations on the aircraft by permitting rapid and continuous time-sharing between IFF antennas. TACAN equipment, which operates in the same band but with only one ground station at a time, can employ the most appropriate of the two antennas on a continuous basis. The DP-318 selects the appropriate antenna for TACAN use automatically on the basis of greatest received signal.

The filter has three terminals: antenna, IFF, and TACAN. At the two IFF frequencies the antenna and IFF terminals are coupled together and the TACAN terminal is isolated. At all other frequencies in the TACAN band the antenna and TACAN terminals are coupled together and the IFF terminal is isolated.



While the automatic selection principle is not new, the DP-318 is the first successful unit to be designed to such small size and weight at no sacrifice in performance characteristics. Now available in production quantities, the unit also meets rigid electrical and environmental requirements so essential to this type of equipment.

Circle Reader Service Card 126

— *m w j* —

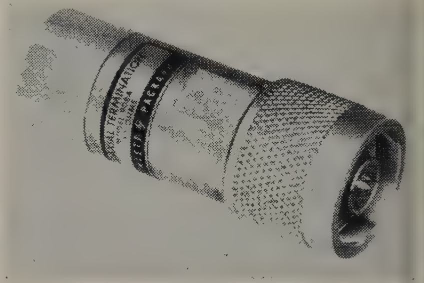
COAXIAL TERMINATION FEATURES LOW SWR OVER WIDE RANGE

A low reflection load for terminating 50 ohm coaxial systems in their characteristic impedance is now available from Hewlett-Packard Co., Palo Alto, Cal.

The coaxial termination, model 908A, has a standing wave ratio of less than 1.05 from dc to 4000 Mc. Because of its low SWR, it is useful for terminating coaxial devices during most SWR measurements, or as a production line impedance standard.

The model 908A is also designed for use as an accessory with the Hewlett-Packard model 185B 1000 Mc Sampling Oscilloscope and the model 411A RF Millivoltmeter. When used with the T adapters available for those instruments it allows the observation of waveforms or the measurement of voltage at the end of a cable with type N fittings.

Power rating of the model 908A is 1/2 watt average; maximum input is 1 kw peak. It is equipped with a type N



male connector, is two inches in length and weighs three ounces. Price is $35 and delivery is two weeks.

Circle Reader Service Card 127

— *m w j* —

SYLVANIA OFFERS COMPACT K-BAND BACKWARD-WAVE OSCILLATOR

Sylvania Electric Products, Inc., Mountain View, Cal., has announced the development of a backward-wave oscillator, type BW-4289, for operation in the 18-Gc to 26.5-Gc frequency range.

The BW-4289 is designed as a voltage-tunable signal source in microwave receiver local oscillator applications, test equipment, and signal-generating equipment. The minimum power output of the tube is 5 milliwatts. It is focused by an integral permanent magnet for compactness and light weight.

The tube is five inches long, 3 1/2 inches in diameter, and weighs five pounds including the magnet. The rf output is fitted with flexible waveguide to simplify mounting the tube in equipment.

The tube is part of a line of backward-wave oscillators that will ultimately cover the frequency spectrum from 12.4-Gc to 100-Gc. R. A. Stonesifer, product sales manager of Sylvania's Microwave Device Operations, said that the next tube in the series, scheduled to become available in June, will cover the 60-Gc to 75-Gc frequency range.

The single-quantity price for the K-band BW-4289 is approximately $3000. Pricing for larger quantities will be furnished on request. Sample quantities can be delivered for evaluation within 60 days.

Circle Reader Service Card 128

— *m w j* —

TRANSCO

Entirely self contained, this new Transco antenna operates efficiently under continuous extreme environmental conditions. Dual radiation pattern coverage is remotely controlled by an integral coaxial switch. With switch de-energized, the radiation is omni-directional in the azimuthal plane; energized, the radiation pattern is cardioid shape with a front to back ratio of −17 db or greater over a range of 225 to 400 MC. For further information, or to apply Transco antenna capability to your new project, please write Transco Products, Inc., 12210 Nebraska Ave, Los Angeles 25, California.

UNITIZED DUAL-PATTERN UHF DATA LINK ANTENNA

COAXIAL SWITCHES • WAVEGUIDE SWITCHES • ANTENNAS • MICROWAVE COMPONENTS • VALVES • ACTUATORS

Circle Reader Service Card 64

NEW LITERATURE

LITERATURE ON CABLE DELAY LINES AVAILABLE FROM AT ELECTRONICS

Round and race track, high accuracy cable delay lines are described in detail in a new catalog sheet offered by AT Electronics, Inc., New Haven, Conn.

Fabricated of Phelps Dodge Styroflex, Spirafil and Foamflex air dielectric, aluminum sheathed coaxial cable, the delay lines are said to be capable of meeting specifications calling for accuracy within ±.02 nanoseconds.

The literature illustrates the variety of "packages" available and includes a chart which provides information on the physical size of a delay line based on the cable dimensions and micro second delay required.

Circle Reader Service Card 130

—mwj—

ANDREW PUBLISHES FLEXIBLE COAXIAL CABLE CATALOG

Andrew Corp., Chicago, Ill., manufacturers of antennas and transmission lines, has published a comprehensive 16 page catalog on Heliax, the flexible airdielectric cable.

The catalog describes in detail the improved electrical and mechanical characteristics of Heliax and accessories now available in 50, 75 and 100 ohms and in a range of sizes from 3/8 to 3 1/8 inches.

Heliax is available from stock in splice free continuous lengths limited only by shipping reel sizes.

Circle Reader Service Card 131

—mwj—

MASTER CATALOG ISSUED BY EMPIRE DEVICES

A comprehensive 56 page, 2 color master catalog has been published by Empire Devices, Inc., Amsterdam, N. Y. It provides complete information on the company's entire line of noise and field intensity meters, impulse generators, power density meters, modulation meters, coaxial attenuators and a wide variety of microwave components.

Included for the first time is a selector chart of fixed and variable attenuators — ranging from single fixed pads to 12 position automatic stepping units — in which the frequency range and maximum power dissipation are charted for each of the many available models. Many recently-developed components are also contained in the new literature, including a standard antenna set for antenna calibration, a series of microwave preselectors, a group of klystron oscillators and a set of broadband hybrid junctions.

For each product in the line, the catalog gives a full description, typical applications, complete specifications and unusual features. Text is augmented with photographs, charts, tabular data, formulas and line drawings as necessary. Of particular interest is a discussion of the impulse generator as a calibrating device, and a gallery of special products which were developed to fill unusual requirements.

Circle Reader Service Card 132

—mwj—

1961-62 ELECTRONIC ENGINEERS MASTER NOW OFFERS RESEARCH REPORTS DIGESTS

The 1961-62 eem—Electronic Engineers Master—is now available and is the largest electronic catalog-directory ever published. Its 1952 pages include 1055 paid catalog pages, an increase of 15 per cent over last year's edition.

A new section — the Research Reports Directory — has been added to eem. It lists and digests over 1000 electronic research reports which are readily available from the U. S. Government. The research was performed by leading government and military installations, universities and private industrial laboratories.

The new edition contains a Catalog section divided into 51 product sections for rapid comparison of similar products; Product Directory providing over 3000 different product types and over 80,000 product sources; Manufacturers' Directory including 6200 manufacturers, their addresses, phone numbers, key personnel, sales offices and representatives; and a Trade Name Index with over 7000 such names listed.

Each of the sections in the 1961 eem is printed on different colored stock.

NEW! Research Reports Directory — Pink Section
1961-62
eem
electronic engineers master
CATALOG

Over 57,000 qualified electronic engineers and purchasing agents are receiving the 1961 edition under the publisher's 'quality-controlled' circulation policy. Non-qualified persons may purchase the catalog-directory for $15 from Tech Publishers, Inc., 60 Madison Avenue, Hempstead, N. Y.

—mwj—

(*Continued on page 124*)

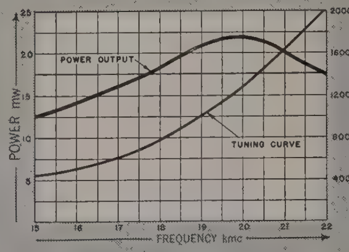
world's shortest short-form catalog on BWOs

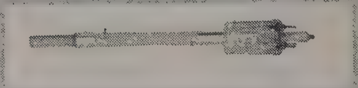
You don't have to send for it
This is it!

TYPE #	FREQ. RANGE kmc	POWER mw
OD 1-2	1-2	50-200
OD 2-4	2-4	30-120
OD 3.7-5.9	3.7-5.9	30-45
OD 4-8	4-8	10-70
OD 5.2-8.3	5.2-8.3	10-40
OD 6-11	7-11	10-40
OD 6-12	6-12	10-30
OD 7-13	8.2-12.4	10-15
OD 10-15	10-15.5	10-20
OD 12-18	12.4-18	10-25
OD 15-22	15-22	10-20

But don't give up if the tube you need isn't listed here . . . these are just the BWOs we usually keep on the shelf in quantity, ready to ship today. We also produce, in either experimental or production quantities, oscillators covering partial, octave, and even greater-than-octave bandwidths.

Would you like a copy of our honest-to-goodness catalog, with complete performance curves, specifications, and operating data? Just drop us a note. Here's a sample set of curves, on the Type OD 15-22 backward wave oscillator:





We'd also like to hear from you if you're interested in permanent-magnet-focused tubes or traveling wave amplifiers.

WESCON
Booth 123

STEWART ENGINEERING COMPANY
Santa Cruz 2, Calif.

Circle Reader Service Card 65

Abstracts from *Russian Technical Literature*. . . of interest to microwave engineers

Translations of complete papers can be made available by contacting Morris D. Friedman, Inc., c/o "the microwave journal," 1330 Beacon Street, Brookline, Massachusetts. Prices are dependent upon length of paper.

RiE, 6(1) (1961)

L. A. Vainshtein, A. A. Fedorov:

SCATTERING OF PLANE AND CYLINDRICAL WAVES ON AN ELLIPTIC CYLINDER AND THE CONCEPTION OF DIFFRACTION RAYS

pp 31-46.

The diffraction of cylindrical and plane waves by a perfectly reflecting elliptic cylinder whose transverse dimensions and radius of curvature are large compared with the wavelength is investigated. An exact solution of this diffraction problem has been obtained in the form of a series and a contour integral, which lead to special functions (attenuation factors) introduced by V. A. FOK, upon the substitution of asymptotic expressions for the radial and angular functions of the elliptic cylinder. The asymptotic solution thus obtained corresponds to the diffraction-ray conception of J. B. Keller and is easily generalized to a convex cylinder of arbitrary shape. This concept thereby receives (in application to problems of this type) additional foundation and, moreover, a certain generalization; in particular, the formulas obtained permit the investigation of the conversion of diffraction rays into ordinary and conversely.

(2F, 16R)

— m w j —

A. S. Goriainov:

DIFFRACTION OF A PLANE ELECTROMAGNETIC WAVE PROPAGATED ALONG THE AXIS OF A CONE.

pp. 47-57.

The exact solution is presented of the problem of plane electromagnetic wave diffraction by an infinite conducting cone in the case when the plane wave is propagated along the axis of the cone. In the region where the scattered field has the shape of a spherical wave formulas are derived which are suitable for numerical computation of the scattering characteristics and results of such computations are presented. Formulas are obtained for the correction-field function due to the narrowing of the surface at the tip of the cone. The graphs presented for these functions permit an estimate of the role of the tip in electromagnetic wave diffraction.

(7F, 5R)

— m w j —

A. N. Sivov:

INCIDENCE OF A PLANE ELECTROMAGNETIC WAVE ON A FLAT GRATING (CASE OF THE H VECTOR PARALLEL TO THE CONDUCTORS).

pp. 58-66.

The electrodynamic problem of looking for the reflection and transmission coefficients during oblique incidence of a plane wave on a flat grating is solved in the case when the H vector is parallel to the grating conductors. The period of the grating is assumed to be small in comparison with the wavelength. The conductor shape and the dielectric filling which is generally different on different sides of the grating are taken into account. The formulas obtained admit a passage to the limit, in particular, as the conductors approach each other without limit. The fields near the conductors are also found. Equivalent boundary conditions are obtained for the grating and the grating-solid metal screen system.

(4F, 7R)

— m w j —

A. IA. Iashkin:

UNIFORM BENDING OF π AND T-WAVEGUIDES IN THE E-PLANE.

pp. 67-73.

A derivation is presented of the system of equations relating the critical mode to the dimensions of the transverse section of π and T waveguides, bent uniformly in the E plane. The application of the systems obtained to a concrete problem is illustrated by an example of the computation of the critical mode of a bent π-waveguide.

(4F, 7R)

— m w j —

B. M. Bulgakov, V. P. Shestopalov, L. A. Shishkin, I. P. Iakimenko:

IRREVERSIBLE WAVE PROPAGATION IN A HELIX WAVEGUIDE PLACED IN A FERRITE MEDIUM.

pp. 81-91.

Electromagnetic wave propagation in a helix waveguide placed in an actual ferrite medium in the presence of a permanent magnetic field applied along the axis of the system is investigated. Th damping coefficient is determined an numerical computations are carried ou of the damping for forward and backward waves.

KHAR'KOV UNIV. *(5F, 5R*

— m w j —

V. P. Shestopalov, A. A. Bulgakov:

COAXIAL RETARDING SYSTEM OF TWO OPPOSITELY WOUND HELICES FILLED WITH A MAGNETODIELECTRIC MEDIUM.

pp. 92-100.

A dispersion equation has been obtained and investigated for coaxial twin oppositely-wound helices placed in a magnetodielectric medium for the helices arranged symmetrically. The influence has been determined of the magnetodielectric on the magnitude of stored power and the total impedance of the system The dispersion properties of the system have been investigated experimentally.

KHAR'KOV UNIV. *(8F, 1T, 5R)*

— m w j —

A. N. Fedotov, B. K. Shembel:

LINEAR ACCELERATOR CAVITY AS THE LOAD OF HIGH FREQUENCY GENERATORS.

pp. 108-116.

The equivalent circuit is analyzed of a linear accelerator cavity with a strong load by a beam taking into account the dependence of this load on the amplitude and phase of the field. The equivalent circuit permits a computation of the input impedance of the accelerator cavity. Experimental results are presented of the operations of a model of an accelerator of a strong load by a beam.

(6F, 1T, 9F)

— m w j —

G. D. Lobov:

GAS DISCHARGE DETECTOR OF MICROWAVE OSCILLATIONS.

pp. 117-124.

The theoretical selection of one of the possible hypothesis of gas-discharge deector operation is explained. On the basis of the analysis, an estimate is given of the magnitude of the duration of the leading edge of a pulse and the transfer coefficient of a gas-discharge detector is determined. An experimental check is made of the theoretical results obtained.

(7F, 4T, 14R)

— *m w j* —

S. B. Rubin:

CERTAIN THEORETICAL QUESTIONS OF MICROWAVE PHASEMETER OPERATION.

pp. 125-136.

The accuracy of operation of separate components of a serrodyne microwave phasemeter is analyzed from the theoretical side. The influence is taken into account of the frequency instability of the klystron generator, of the non-ideality of the characteristcs of the serrodyne method of frequency shifting, the presence of standing waves in waveguides, the non-ideality of the amplitude limiters and phase detectors in the occurrence of periodic phase drifts in the high and low-frequency channels of the phasemeter.

(5F, 5R)

— *m w j* —

A. L. Igritskii:

OPTIMUM ELECTRON BEAM FOCUSSING IN A PERIODIC TWT FOCUSSING UNIT.

pp. 137-145.

A new analytic method is proposed to determine the parameters of a periodic TWT focussing unit for optimum electron-beam focussing. It is proved that the method proposed guarantees considerably less waviness of the electron beam in the periodic unit than the method of Chang presently being used. The new method permits production of a prescribed, normal electron-beam configuration, which also depends on conditions at the electron input to the periodic unit. It is shown that the best focussing conditions are obtained for the electrons entering the periodic field at maximum induction.

(5F, 2R)

— *m w j* —

M. B. Tseitlin, E. M. Il'ina:

TRAVELING WAVE TUBE GAIN FOR FINITE VALUES OF THE GAIN PARAMETER C.

pp. 170-175.

The energy method of computation proposed in (4) (RiE, 5(4) (1960)) permits a comparatively simple determination of TWT gain for finite values of the gain parameter C. This method consists in seeking the distribution of the amplitude of the HF field intensity along the tube from the active power balance equations. It is here assumed that the field in the line can be represented by a single wave with constant phase rate.

(8F, 6R)

— *m w j* —

IVUZ, RF, 3(6) (1960)

A. Khanberdiev, N. L. Kaidanovskii:

TRAVELLING WAVE TUBE AS A PHASE MODULATOR FOR A RADIO INTERFEROMETER.

pp. 943-948.

The possibility is considered of using a TWT as a phase modulator for a radio interferometer. The parasitic amplitude modulation at the phase modulation frequency and its harmonics are investigated. A comparative appraisal is made of a TWT modulator.

MAIN ASTRON OBSERV. AN USSR
(7F, 1T, 7R)

— *m w j* —

A. N. Malakhov:

FLUCTUATIONS OF THE TRANSFER COEFFICIENT OF A CRYSTAL DIODE MIXER

pp. 1001-1003.

The fluctuations are analyzed of the transfer coefficient of a crystal mixer with a klystron heterodyne. These fluctuations are generated by the flicker-noise of the crystal and by the fluctuations in the amplitude of the klystron oscillations. It is shown that the spectral density of the relatve fluctuations of the transfer coefficient is $\delta K_f^2 \simeq (10^{-7} - 10^{-10}) f$ at the frequency f.

MIRFI, GOR'KII UNIV. *(1F, 3R)*

— *m w j* —

A. N. Malakhov:

PASSAGE OF A QUASI-MONOCHROMATIC SIGNAL THROUGH AN UNSTABLE MIXER.

pp. 1004-1009.

The passage of oscillations with a definite spectral line width through a mixer whose heterodyne is also not monochromatic and whose transfer coefficient experiences are analyzed. It is shown that the shape of the spectral line of the oscillations at the mixer output differs substantially from that at the input and this distortion is due first to the heterodyne voltage being not monochromatic and second to the fluctuations of the mixer transfer coefficient.

NIRFI, GOR'KII UNIV. *(4R)*

— *m w j* —

A. M. Beliantsev:

ON THE THEORY OF COUPLED RESONATORS.

pp. 1022-1032.

Integro-differential equations are obtained which describe the free and forced oscillations of a system of coupled resonators. The resonators are mutually coupled through a narrow parallel slot in a metallic cylinder whose transverse dimension is much less than the wavelength of the oscillations being investigated. The free oscillations are analyzed of a system of two rectangular resonators mutually coupled through a narrow slot in a "thick" screen. The dispersion characteristics of a ribbed waveguide are found.

NIRFI, GOR'KII UNIV. *(3F, 7R)*

— *m w j* —

Abstracts of the following papers can also be made available.

Ferrity — Fizicheskie i Fiziko-Khimicheskie Svoistva Ferrites — Physical and Physical-Chemical Properties. Reports to the III All-Union Conference on the Physics, Physical-Chemical Properties of Ferrites and the Physical Principles of their Application. Minsk, 1959

Akad. Nauk BSSR Press, Minsk,
1960, 655 pp.

TABLE OF CONTENTS

N. N. Sirota:

THIRD ALL-UNION CONFERENCE ON FERRITES (OPENING REMARKS).

E. A. Turov, Iu. P. Irkhin:

ON THE PHENOMENOLOGICAL THEORY OF THE ELECTRICAL CONDUCTIVITY OF FERRITES AND ANTIFERROMAGNETS.

S. V. Tiablikov:

ON A METHOD OF COMPUTING THE THERMODYNAMIC CHARACTERISTICS OF FERROMAGNETS IN A WIDE TEMPERATURE RANGE.

N. S. Akulov:

ON THE THEORY OF THE RECTANGULAR HYSTERESIS LOOP.

E. A. Turov, A. I. Mitsek:

ON THE THEORY OF THE TEMPERATURE DEPENDENCE OF THE MAGNETIC ANISOTROPY CONSTANTS OF FERROMAGNETS AND FERRITES.

B. V. Vlasov, B. Kh. Ishmukhametov:

ROTATION OF THE PLANE OF POLARIZATION OF ELASTIC WAVES IN MAGNETICALLY-POLARIZED MAGNETO-ELASTIC MEDIA.

L. N. Syrkin:

COMMENTS ON THE REPORT.

N. N. Sirota:

PHYSICAL-CHEMICAL NATURE OF FERRITES AND THEIR PROPERTIES.

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New Literature

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BULLETIN TELLS SHORT CUTS IN HOLDING MAGNET DESIGN

A new four page Engineering Bulletin from Indiana Steel Products Division, Indiana General Corp., Valparaiso, Ind., explains a simplified method for designing holding magnets and assemblies. Only three factors — required pull, air gap, and geometric shape of the proposed magnet — are needed for quick and accurate design calculations.

Twenty-four basic designs for holding magnets and their performance characteristics are included in the bulletin.

The new Bulletin, entitled "Shortcut for Holding-Magnet Design" contains complete data for Alnico and Indox permanent magnets.

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BULLETIN DESCRIBES MINIATURE RF MAGNETIC COMPONENTS

Custom miniature RF magnetic components are illustrated and described in Bulletin 561 released by Applied Components Inc., Inglewood, Cal.

Included are data sheets on encapsulated radio frequency transformers used in airborne balanced modulating systems, crystal filters and radar receivers. Also included is information on radio frequency antenna coils packaged in modular form. Usage. application, electrical and environmental performance is detailed.

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REPRINTS ON "DEVELOPMENT IN ATTENUATION MEASUREMENTS" AVAILABLE

The Weinschel Engineering Co., Kensington, Md., has available a limited number of reprints of a report entitled, "Development in Attenuation Measurements and Standards."

The report, written by Bruno O. Weinschel, president of the Kensington firm, was originally presented to the XIII General Assembly of URSI. It was then printed in the Journal of Research of the National Bureau of Standards.

The report first defines several of the terms used in attenuation measurement and then describes the various techniques for making these measurements. It is fully annotated and contains a complete bibliography.

Reprints of the report may be obtained by writing the Weinschel Engineering Co., 10503 Metropolitan Avenue, Kensington, Md. Because of the limited number of reprints available, all requests must be made on corporate letterhead.

—*mwj*—

BOOKLET DESCRIBES GE'S MICROWAVE POWER FILTERS

Information on the microwave power filters of the General Electric Co., Schenectady, N. Y., is available in the new booklet, PT-52.

The 16 page booklet describes five GE filters designed to suppress harmonics generated in high-power transmitters ranging from 400 - 6000 Mc. In addition, it shows how use of the filters can increase fundamental power-handling capacity by absorbing unwanted harmonic signals.

The illustrated booklet also contains a consolidated data sheet and outline drawings of GE's S-Band filters, types MPF-2501 and MPF-2502; L-Band filter MPF-1001; UHF filter MPF-400; and C-Band filter MPF-4000.

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CATALOG DESCRIBES FITTINGS, MIL-STANDARD FORGINGS

Pem Machine Tool Co., Hillside, N. J., has issued a new catalog which describes its finished fittings and its broached and unbroached Mil-standard forgings.

The Mil-standard flanges — cover, choke and contact — are manufactured in strict accord with specification MIL-F-3922 from forgings, castings or bar stock. In addition to "regular fittings" of brass and aluminum, — the company also supplies magnesium and oxygen-free copper flanges.

Pem's open stock of conventional fittings is augmented by its custom components section, which will supply individual broaching and machining requirements.

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—*mwj*—

PROCEEDINGS OF ELECTRONIC COMPONENTS CONFERENCE AVAILABLE

The proceedings of the 1961 Electronic Components Conference, which was held in San Francisco May 2 - 4, is available through headquarters of sponsoring organizations (American Institute of Electrical Engineers, the Institute of Radio Engineers, Electronic Industries Association, and Western Electronic Manufacturers Association)

The proceedings covers sessions "Transistors and Solid State Devices," "Progress in Component Reliability," "High Voltage Components," "Microwave Components," "Components, Resistors, Capacitors" and "Microminiaturization, Space Components, Materials and Related Devices."

It includes 38 papers and 540 pages, and price is $9.

—*mwj*—

MOORE ISSUES BULLETIN ON MICROWAVE ALARM CONTROL SYSTEMS

Publication of an information bulletin on microwave alarm and control systems has been announced by Moore Associates, Inc., San Carlos, Cal.

The two-page, two-color bulletin discusses the feature of the basic Moore Associates microwave alarm and control systems, the MARC 3000 and the MARC 4000. Both systems provide for continuous transmission of information regarding the operation of remotely located apparatus.

The systems described in the bulletin feature completely solid-state circuits with a capacity for 65 alarm reports per second. An attendant can also determine specifically which monitored functions at any one remote station are normal or in alarm. Several remote-control options are available to fit the specifications of the user.

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—*mwj*—

DIGITAL, RF SYSTEMS CATALOG AVAILABLE FROM DYMEC

A new 16 page catalog of digital and rf systems and instruments is available from Dymec, a Division of Hewlett-Packard Co., Palo Alto, Cal.

The catalog provides information on the three major product groupings manufactured by Dymec. One section covers programmable digital systems for data handling, component testing, automatic measurement and control applications. Typical systems are described, and specifications are given on input devices, digitizing equipment, and output devices.

A second section of the catalog describes the techniques used by Dymec for manufacturing rf checkout equipment used for production and field testing and performance monitoring of missile, satellite and airborne electronic systems.

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(*Continued on page 127*)

BOOK REVIEW

OPTICS OF THE ELECTROMAGNETIC SPECTRUM *by C. L. Andrews; Prentice-Hall, 1960, 492 pp, 9 index pp, x ($9.00).*

This text has the laudable aim of teaching optics through carefully designed experiments using microwave equipment. Interference and diffraction patterns can then be measured with large non-precision equipment, i.e., meter sticks.

The book succeeds very well in this regard. The nineteen chapters can be grouped by topical material. The first four cover history, generation and detection of electromagnetic waves, wave propagation, and the velocity of light. The latter chapter discusses the many measurement techniques including recent experiments utilizing microwaves. In the next group of chapters are included standing waves, wave interference, Michelson's interferometer, and thin film interference. These chapters are typical of the strong and weak points of the book. In the standing wave chapter, the discussion of waveguides and standing waves is so abbreviated that the optics student will get at best a fragmentary understanding.

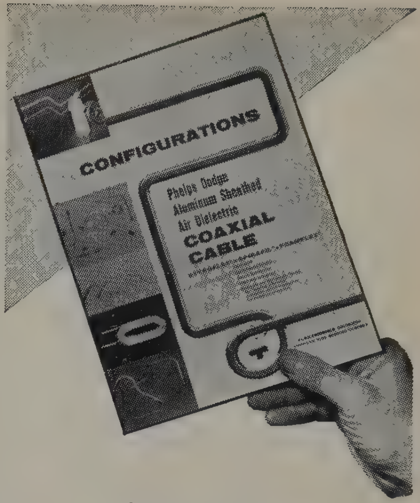
The interference chapters, however, are excellent, making full use of both the appropriate equations and plots of amplitude and phase, etc. Among the interesing topics covered are Fresnel biprism and mirror, Young's double slit experiment with microwaves, the analogy between Michelson's interferometer and a properly terminated hybrid junction, and the step gage in increments of 10 molecular layers.

The next group of chapters covers Fraunhofer and Fresnel diffraction and diffraction gratings. The derivation of the scaler approximate (Kirchhoff) diffraction by a circular aperture is given in detail. Demonstration of Fresnel zones is a typical experiment best performed with microwaves. The next chapter on electromagnetic theory is in a class by itself. Derivations of the Gauss and Ampere laws are given; the wave equations and the concept of displacement current are developed without use of vector notation. Here again the treatment is exceedingly sparse. All through the work and especially here, reference to the many extant excellent and appropriate works on electromagnetic theory would have been most valuable. However, only a few not well chosen references are given.

The last group of chapters cover quantum absorption and scattering, dispersion, double refraction, and polarization. Under scattering is included Compton and Raman processes. The dispersion chapter is good on optics but weak on artificial dielectric coverage. Wavefront treatment in birefringent media is very good, including Nicol prism and quartz prisms.

In summary, for optics students the book is good in using microwave techniques as pedagogic tools, but the microwave expository material is very sketchy and poorly referenced. The book is, I believe, also valuable to those versed in the microwave art who wish to learn classical optics; here the sparse microwave treatment is no disadvantage and the opics treatment is good.

Reviewed By
R. C. Hansen
Associate Editor
the microwave journal



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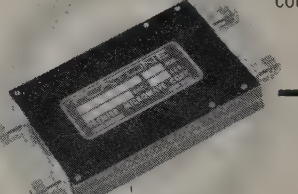

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(*Continued from page 125*)

FXR DEMONSTRATES SPECIAL PRODUCTS CAPABILITIES IN NEW BROCHURE

Special Products of the Microwave Division of FXR, Inc., Woodside, N. Y., are displayed in a four page two color brochure.

Among the Special Products illustrated and described in capsule form are a radar test set for missiles, high power rotary joint, stripline power divider, resistive loop directional coupler, three port switch, optical waveguide arc detector, high resolution frequency meter, power peaker, electrically variable attenuator, audio function generator, and others.

The brochure describes the multiple capabilities of the microwave division in special products design and also lists the engineering and production facilities of FXR for prototype or production runs.

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—mwj—

SPEC SHEET DESCRIBES WEINSCHEL'S PRECISION ATTENUATOR SET

A new two page specification sheet on the Weinschel Model AS-1 Precision Attenuator Set is available from the Weinschel Engineering Co., Kensington, Md.

The set, especially prepared for use in standards laboratories, contains four Weinschel Model 210 attenuators and four Weinschel Model 50 attenuators in values of 3, 6, 10, and 20 db, covering a frequency range of dc to 12.4 kMc. The attenuators have stainless steel bodies and connectors and come in a solid walnut, lined instrument case.

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ARTICLE AVAILABLE ON SOLID-STATE CONTROL OF MICROWAVES

A six page article on Solid-State Control of Microwaves is available on request from the Electron Tube & Device Division of Microwave Associates, Inc., Burlington, Mass.

The paper discusses the applications of semiconductor diode devices which use varactors in microwave switching, phase-shifting, duplexing and limiting. It summarizes typical performance capabilities of solid-state control devices which are now commercially available.

The paper is designed to be a concise introduction to the basic uses of varactor diode devices in instances where nanosecond switching speeds and all-solid-state reliability are advantageous.

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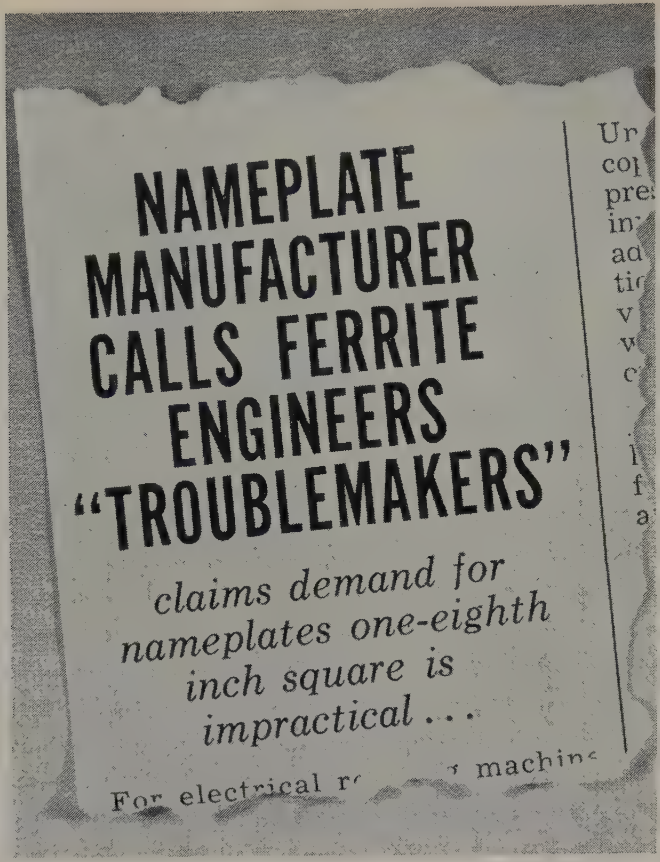

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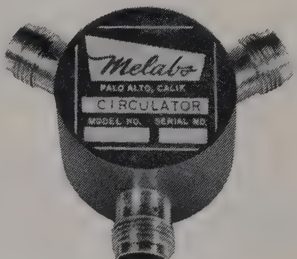

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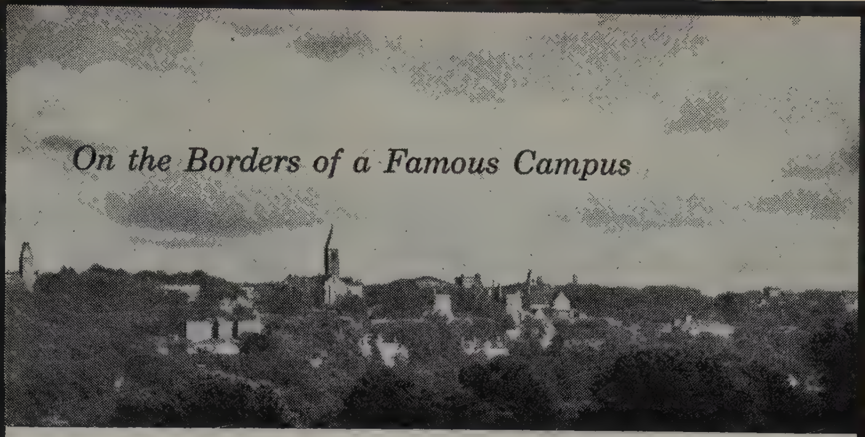
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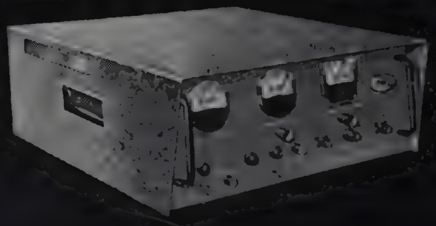

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the challenge of millimeter waves

By B. G. RYLAND

Several scientific developments in the past year have led to a new emphasis being placed on that portion of the electromagnetic spectrum currently being utilized by existing microwave systems and visible light. This area, which has tempted the imagination of the scientific worker for many years, is now attracting the attention of those guiding product development in the electronics industry.

The submillimeter spectrum represents a challenge to the electronics industry of several dimensions.

The first dimension of this challenge is a scientific and technical one. In spite of the fact that many of the gross characteristics of radiation at millimeter and submillimeter wavelengths have been known or can be deduced with reasonable certainty from observations made on either side of the gap, there is still a great unexplored area of investigation covering the characteristics of such radiation, the properties of materials, and the natural resonance phenomena that may exist within this region — not to mention the physiological effects which are perhaps less well understood outside of the gap as well.

It is difficult to assess in advance the amount of scientific thought that will be required to gain a thorough understanding of any portion of a scientific field — indeed it is almost impossible even to define a scientific area in such a way that the definition will remain meaningful for a relatively long period of time. But, based on the work accomplished thus far in experimental confirmation of scientific hypotheses or in the gathering of empirical data, the experimentalist will fare in this region technical difficulties well beyond those met and overcome at lower frequencies.

Experimental work in the millimeter and submillimeter wavelength decades depends fundamentally on the measurement of wavelength and the construction of scientific apparatus whose dimensions are almost universally a direct function of wavelength. Shrinking these dimensions by an order of magnitude infers most significantly a demand for an increase in precision of an order of magnitude or more. We have left the range of investigation where the wavelength was a convenient compromise between the massive and awkward and the miniature and imperceptible. The important elements of the experiment may well be so small that only translation through optical magnifiers will bring them into the range of judgement of the eye; much of the sophisticated instrumentation of molecular and atomic studies may be required.

Length is not the only dimension which begins to recede into the realm of the unmeasurable. Higher frequency also infers a measurement of shorter elements of time. Certainly, the advent of radar and its exploitation has brought the microsecond to be a familiar friend in the laboratory, with the nanosecond following on its heels. In the range of submillimeter phenomenon, however, there will be events which will occur in time periods well beyond the resolving power of present day instruments.

Signs today rather clearly indicate the magnetic fields of a higher order of magnitude will also accompany the pursuit of scientific knowledge into the millimeter and submillimeter regions. These fields appear essential to the translation of centimeter tubes into the submillimeter — either for focusing beam type tubes or for the essentials of crossed field tubes. But they are also necessary for the measurement and utilization of the characteristic resonances that occur in materials in the millimeter and submillimeter frequency decades.

Experimental work in this region can also be expected to expand into little touched ranges of power density. Though absolute powers are not large at this time, viewed in terms of coherent power density, the quantities

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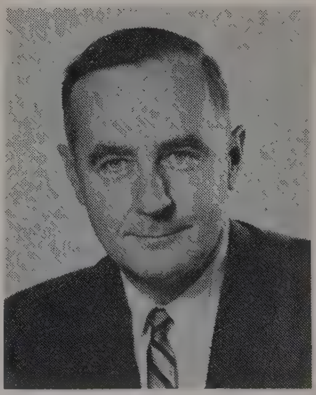
BERTRAM G. RYLAND attended Stanford University where he received his BS and MS degrees in electrical engineering in 1947 and 1948, respectively, and the Degree of Engineer in 1954.

He was employed by the General Electric Commercial and Government Equipment Division, Syracuse, N.Y. in 1948 and was transferred to the GE Applications Engineering Department.

In 1951 Mr. Ryland returned to Stanford University as a research associate in the Electronics Research Laboratory. He rejoined General Electric in 1955 as a project engineer in the Microwave Laboratory, Palo Alto, California. In 1959 he joined Raytheon Company and at present he is Director of Engineering of the Microwave and Power Tube Division and Manager of the Spencer Laboratory.

He is a member of Sigma Xi and the Professional Group of Electron Devices of the IRE.



are significant. Again, the measurement and utilization of such power density is a challenge of the times.

Most of the areas of research in this next segment of the frequency spectrum are intimately dependent upon suitable sources of coherent power for the experiments that must be performed. As a consequence, the region becomes a particular challenge to the organization in the industry devoted to this type of electronics. Not only are the broadband devices needed to provide sufficient power to measure quantities such as transmission coefficient, dielectric constants, permeabilities, and absorption resonances with reliability, but there is also a need for devices capable of delivering the higher power outputs at specific frequencies to permit the penetration into the realm of high power density and the non-linearity or saturation effects to be expected.

The challenge of the millimeter and submillimeter decades lies not alone in the scientific aspects, but there is also a tremendous challenge in the application of this scientific knowledge to the pressing problems of the modern age. There is a true marketing challenge taken in the broadest sense of the word; a challenge to match the integrated scientific knowledge with personnel oriented to the needs of society and to create systems, equipments, or products which successfully and uniquely satisfy a need.

There has been seemingly more success with respect to the military and defense needs of this country than there has been in recognizing the non-military applications.

Much of the research and development activity has been predicated in varying degrees on the extrapolation of existing military systems into this higher frequency area. These systems encompass the broad areas of radar — two-way transmission systems for navigation, target location and identification, surveillance, et cetera — and of communications — one-way transmission systems in which intelligence is contained in the transmitted signal to be carried to the distant receiver.

In approaching millimeter and submillimeter wave systems from the base of experience at lower frequencies, it becomes evident that there must be clear reasons to employ these higher frequencies. There is no doubt that otherwise equivalent systems will cost more at millimeter wavelengths, especially in this era in which much development work must be undertaken and when only small quantities are to be produced.

But there are unique properties associated with millimeter wave radiations which can be converted to economic value. Bandwidth may well be ultimately recognized as the most valuable of these properties. The sheer immensity of the information bandwidth available in this region gives hope that systems in this portion of the spectrum, combining utilization of narrow radiation beamwidths or some form of confined transmission, will provide the opportunity to continue to expand the flow of information in the modern art of communications. It would appear that communications links in the millimeter region may be indispensable as data processing machines are designed to operate at higher and higher speeds and their interconnection becomes the accepted means of transmitting and interpreting data.

The narrow beamwidths obtainable with reasonable-sized antenna can also be expected to be exploited as advantages of millimeter wave radiation. Secrecy in communications systems, anti-jam properties in military systems, and ultimately a high degree of system over-all efficiency can be expected from perceptive balancing of the factors involved.

The interesting absorption characteristics of many of the gases of the earth's atmosphere that appear in the millimeter and submillimeter decades may seem at first to be only unwanted detriments to the realization of reliable communications systems and precision radars. And certainly in some instances such is the case, but two important points should not be overlooked: (1) these phenomena will not be factors in the design of systems to operate outside of the earth's atmosphere (even attenuation through the entire atmosphere in a vertical direction is not particularly high), and (2) these phenomena suggest a means of seeing the atmosphere and measuring some of its transient states. This second point can lead to systems for improved navigational aids for aircraft and to an effective new tool for meteorological observations.

The higher frequencies also offer some considerations in the equipment size which to date have been difficult to realize in practice. For a number of applications, the total equipment should shrink in proportion to its wavelength. Practical considerations, however, have prevented this since most components fail to maintain their lower frequency efficiency and there is also a demand to retain connections to many of the microwave components at their present size to permit accustomed handling.

Certainly there is justification for a desire to keep as many of the microwave circuit elements within a single package if for no other reason than to avoid the problem of interconnection with small tolerances. It would seem that we are facing the microwave equivalent of the microelectronic concept to the circuit problem. Some of the same basic questions can be expected to arise — how much of this circuit is designed and supplied by the component manufacturer; what sort of standardization of package characteristic should be obtained; who, how many, and what kind of elements can be included in the package before the losses due to single element failure counterbalance the gains from the reduction of interconnection costs?

The third dimension of the challenge of the millimeter and submillimeter decades is one of timeliness. For several years activity in this part of the spectrum has been confined to relatively few dedicated workers. With the recognition of some of the promises of millimeter radiation in terms of present day needs, there will be an increasing pressure to make available the necessary components to prove and utilize the system concepts being evolved. There will be a demand to make up the time lost since the rapid expansion into the centimeter wave region during and following World War II.

There is still much that can and will be accomplished in this gap in the spectrum. Individual workers, and organizations as well, will find that their ideas must be reduced to practice and published quickly if they are not to find similar contributions made by others.

The use of shorter wavelength radiation stands as a major frontier of the electronics industry today. The next few years can be expected to find the results of work currently underway providing systems and instrumentation for contributions in the fields of communications; surveillance and guidance by radar, navigation, and meteorology; as well as to basic studies of the physical properties of matter.

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9-75 ☐ Diplexers
0-76 ☐ Terminations

9-76 ☐ WAVEGUIDES
0-77 ☐ Rigid
1-77 ☐ Flexible
5-73 ☐ Transitions
3-77 ☐ Windows

0-78 ☐ MILLIMETER ______________________
Type

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3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	41	42	43	44	45

53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	86	87	88	89	90

Complete this section ONLY if you are PRINCIPALLY engaged in any activities listed below. 0-33

☐ Please check here if you are engaged in Research and Development work and if your activities encompass general phases of "the microwave journal".

3-79 ☐ MAGNETICS ______________________
Type

9-79 ☐ CRYOGENICS ______________________
Type

3-86 ☐ PLASTICS
5-86 ☐ Radomes
7-86 ☐ Insulation
9-86 ☐ Packaging
0-87 ☐ Dielectrics
1-87 ☐ Absorbers
3-87 ☐ Other ______________________
Type

5-87 ☐ MATERIALS
7-87 ☐ Garnets
9-87 ☐ Germanium
3-88 ☐ Galium arsenide
5-88 ☐ Inter Metal. Comp.
1-88 ☐ Ferrites
7-88 ☐ Rubies
9-80 ☐ Silicon
9-88 ☐ Other ______________________

0-89 ☐ PLASMA ______________________
Field

5-89 ☐ SPECTROSCOPY

7-89 ☐ OPTICS

9-89 ☐ NUCLEAR
0-90 ☐ Linear Accelerator
1-90 ☐ Cyclotron
5-90 ☐ Atomic beams
3-90 ☐ Other ______________________

9-90 ☐ FERROELECTRICS

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Please check the areas in which you are **PRINCIPALLY engaged.**

☐ DEVELOPMENT
☐ DESIGN
☐ RESEARCH
☐ EXECUTIVE
☐ APPLICATIONS
☐ PURCHASING
☐ PRODUCTION
☐ EDUCATION
☐ SALES
☐ MAUNFACTURERS REPS.
☐ OTHER

If you are working for Government, please specify ☐ Civil or ☐ **Military Agency.**

Do you wish to receive *the microwave engineering handbook and catalog purchasing guide?* ☐

FOLD

Complete this section ONLY if you are **PRINCIPALLY engaged in SYSTEMS.** 0-25

0-26 ☐ **RADAR** ______________
Type
1-27 ☐ **MISSILES**
3-28 ☐ Tracking 5-28 ☐ Guidance
9-28 ☐ Other
3 30 ☐ **GROUND SUPPORT** ______________
Type
7-28 ☐ **AIRBORNE** ______________
Type
0-31 ☐ **ASW** ______________
Type
7-31 ☐ **TELEMETERING** ______________
Type
9-32 ☐ **DATA PROCESSING** ______________
Type
5-34 ☐ **RADIO ASTRONOMY** ______________
Type
1-32 ☐ Radiometry 7-34 ☐ Other
1-41 ☐ **COUNTERMEASURES** ______________
Type
3-41 ☐ **POINT TO POINT RELAY LINKS**
5-42 ☐ Commercial MW Relay User
☐ Industry served ______________
9-42 ☐ Relay equipment manufacture

5-41 ☐ **DETECTION SYSTEMS**
7-41 ☐ Infrared
9-41 ☐ Other ______________
Type
1 43 ☐ **SONAR**
3-43 ☐ Ultrasonics
5-43 ☐ Other ______________
Type
1-44 ☐ **COMMUNICATIONS**
3-44 ☐ UHF, VHF
5-44 ☐ Space Communications
7-44 ☐ SSB Trans.
9-44 ☐ Radio, Television
7-45 ☐ Mobile
9-45 ☐ Data Transmission
3-45 ☐ Other ______________
Type
0-63 ☐ **SUBSYSTEMS**
1-63 ☐ Power supplies
1-45 ☐ Transmitters
0-45 ☐ Receivers
9-63 ☐ Circuits
7-63 ☐ Other ______________
Type

FOLD

Are you a graduate engineer? ☐ Yes ☐ No Type of degree ______________

If you are principally engaged in component activity, (Tubes, Antennas, Hardware, etc.).

1. — Is your principal activity to develop and/or manufacture components for direct sale? ☐ Yes ☐ No

2. — Is your principal activity to produce and/or develop components for in-company systems manufacture? ☐ Yes ☐ No

3. — If your answer to Question #2 is "Yes" please specify system or field of activity.
____

4. — Do you use the "bingo" card service? ☐ Yes ☐ No

5. — Is the "bingo" card service a ☐ valuable ☐ useful ☐ meaningless tool?

6. — Does the advertiser respond to your "bingo" card request with ☐ literature or a ☐ sales call?

7. — Are you contemplating using ☐ masers or ☐ parametric amplifiers in your systems?

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1 Mw to 25 Mw

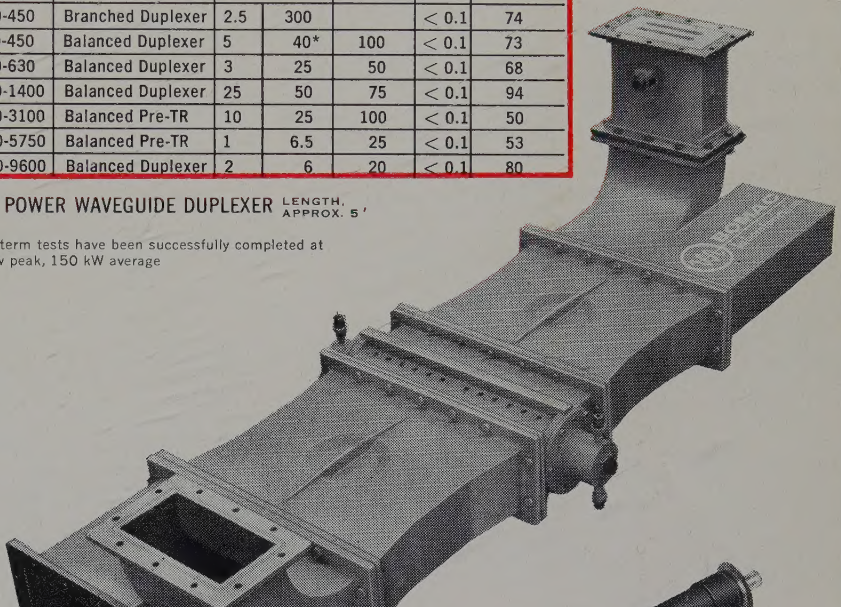
Bomac presents a state-of-the-art advancement in high-power, low-frequency duplexers. Applications include a wide variety of radar services and systems.

These duplexers are available in both waveguide and coaxial line configurations. Peak power ratings: 1 Mw to 25 Mw. Frequency range: 450 to 9600 Mc. Life expectancy: greater than 2000 hours.

Improved window design provides increased radar capability. Arc loss: much less than 0.1 db. Recovery time at high power is the fastest of any gas switching duplexer on the market. With increased power, recovery time increase is negligible.

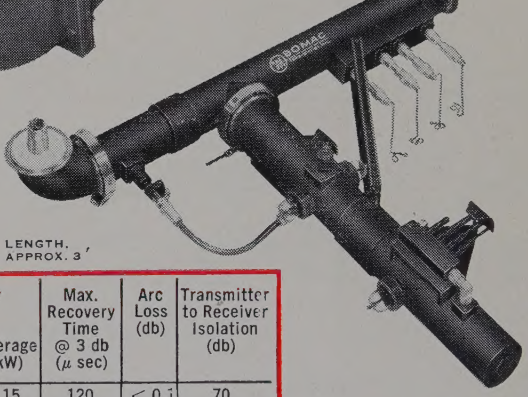
Write for additional information, including power level and frequency desired.

Frequency (Mc)	Duplexer Type	Power		Max. Recovery Time @ 3 db (μ sec)	Arc Loss (db)	Transmitter to Receiver Isolation (db)
		Peak (Mw)	Average (kW)			
400-450	Branched Duplexer	2.5	300		< 0.1	74
400-450	Balanced Duplexer	5	40*	100	< 0.1	73
570-630	Balanced Duplexer	3	25	50	< 0.1	68
1250-1400	Balanced Duplexer	25	50	75	< 0.1	94
2700-3100	Balanced Pre-TR	10	25	100	< 0.1	50
5250-5750	Balanced Pre-TR	1	6.5	25	< 0.1	53
8400-9600	Balanced Duplexer	2	6	20	< 0.1	80



HIGH POWER WAVEGUIDE DUPLEXER LENGTH, APPROX. 5′

*Short term tests have been successfully completed at 95 Mw peak, 150 kW average



HIGH POWER COAXIAL LINE DUPLEXER LENGTH, APPROX. 3′

Frequency (Mc)	Duplexer Type	Power		Max. Recovery Time @ 3 db (μ sec)	Arc Loss (db)	Transmitter to Receiver Isolation (db)
		Peak (Mw)	Average (kW)			
400-450	Balanced Duplexer	3	15	120	< 0.1	70
400-450	Branched Duplexer	3	5	100	< 0.1	60
850-950	Balanced Duplexer	2	15	100	< 0.1	70

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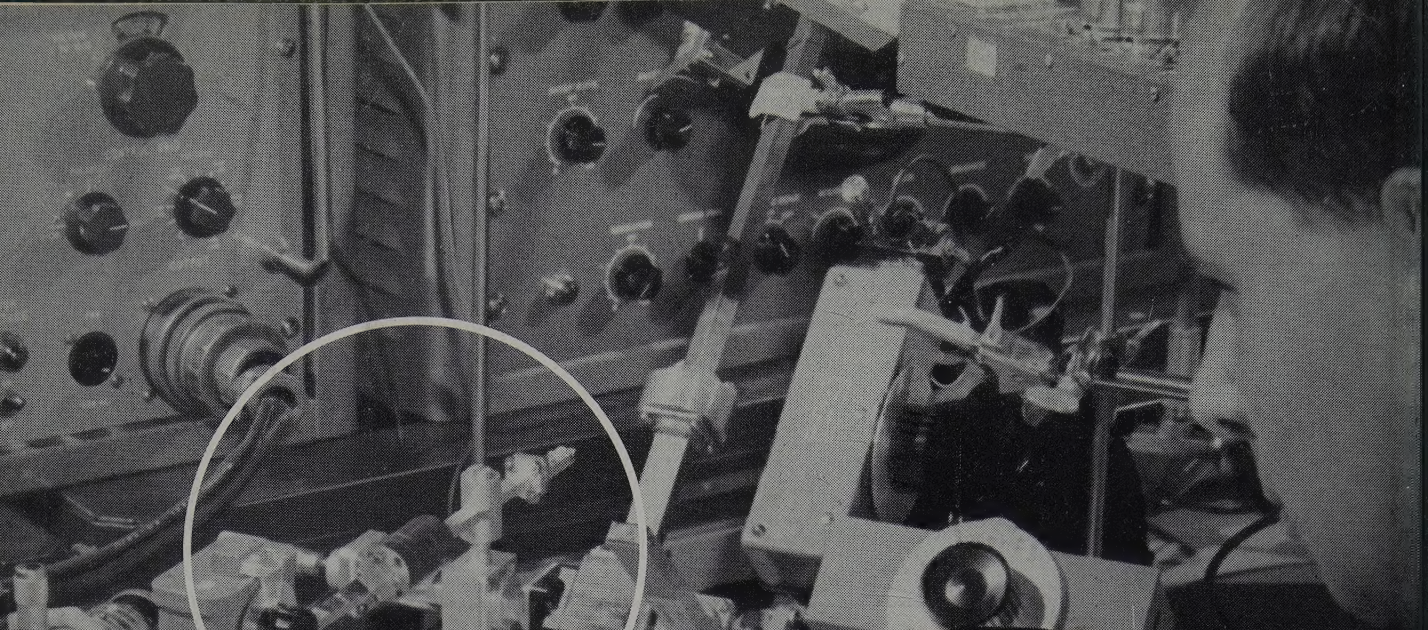
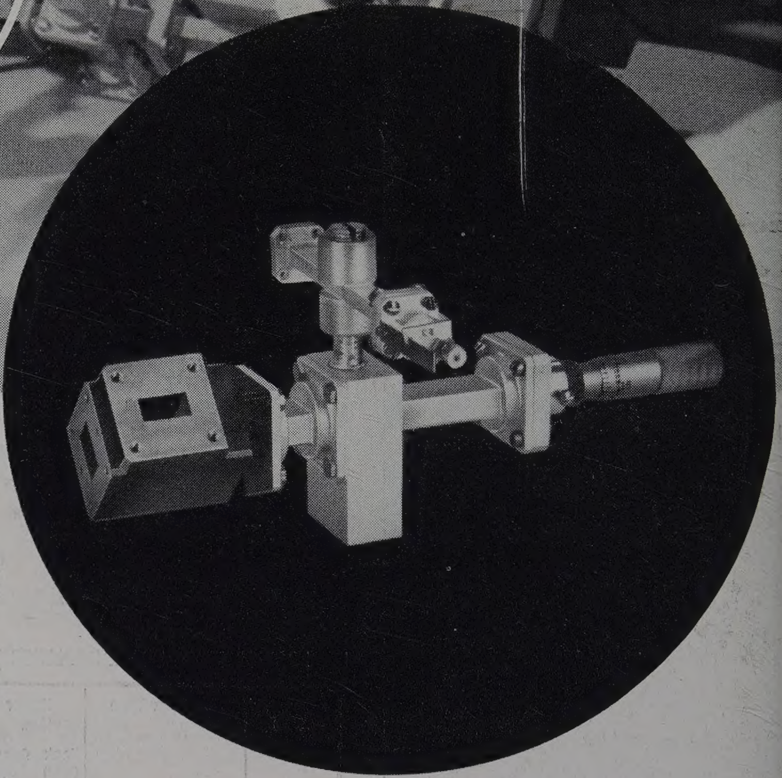


K$_E$-BAND RECEIVER TEST SETUP shows Raytheon parametric amplifier in operation. Unit as supplied is shown at right.



Raytheon parametric amplifier

has lowest noise figure yet reported at K$_E$ band

New degenerate amplifier has noise figure of 3 db with double sideband signal

This parametric amplifier offers a greater signal-to-noise advantage than any yet announced for 13.5 kMc operation. The model described here is ideally suited for application as a pre-amplifier in MTI radar receivers. However, Raytheon can supply units with comparable performance at other frequencies to meet your particular requirement.

Write today for details on this or other Raytheon developments in microwave devices. Special Microwave Devices Operation, Raytheon Company, Waltham Industrial Park, Waltham, Massachusetts.

TYPICAL SPECIFICATIONS	
Mode of Operation	Degenerate
Signal Frequency	13.5 kMc
Pump Frequency	27 kMc
Noise Figure (double sideband)	3 db max.
Gain	17 db min.
Bandwidth	10 Mc min.
Tunability of Amplifier	10% min.
Typical Pump Power (Function of Diode)	50 mw max.
Weight (includes 6 oz. circulator)	2.0 lbs.

RAYTHEON

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SPECIAL MICROWAVE DEVICES OPERATION